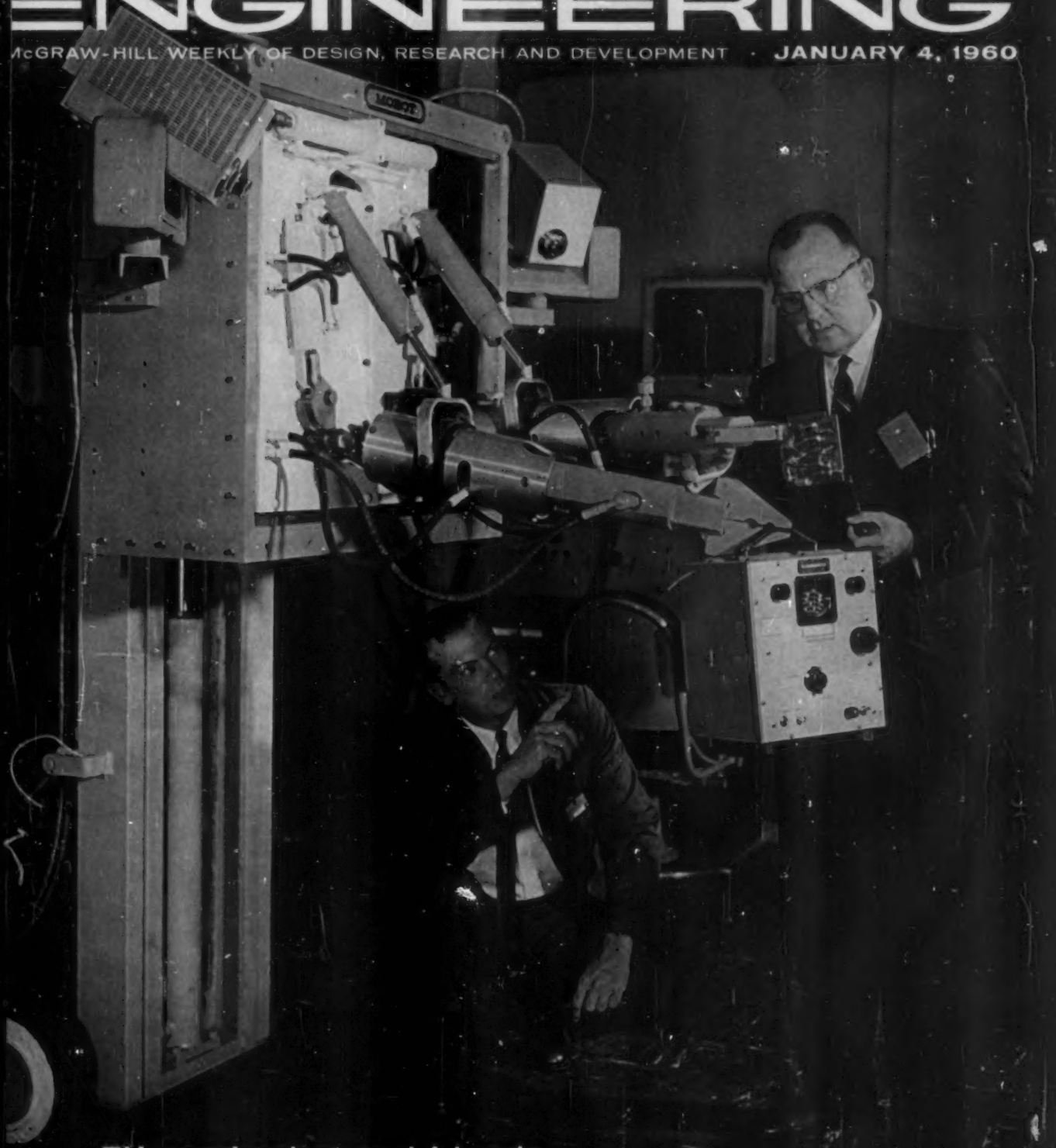
PRICE 50 CENTS

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · JANUARY 4, 1960

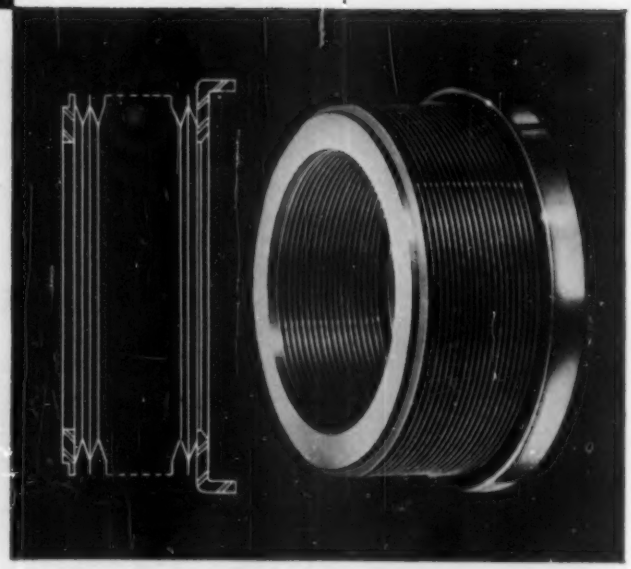


TV-eyed robot and friends . . .

see page 3

C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1237 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities

In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

CIRCLE 201 ON READER SERVICE CARD

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

January 4, 1960 Vol. 31, No. 1

FEATURED:

DEPARTMENTS:

INTERESTING TO NOTE 3
COMING NEXT WEEK 4
DEVELOPMENTS TO WATCH 7
WHAT'S HAPPENING IN RESEARCH 9
FROM WASHINGTON 13
THE ENGINEERING WEEK 15
POINTS OF VIEW 24
READER TO EDITOR 28
COMING EVENTS 28
HORIZONS 35
PRODUCT DESIGNS 45
SIGNIFICANT COMPONENTS 62
NEW BOOKS 71
DESIGN ABSTRACTS 74
CATALOGS AND BULLETINS 74
CURRENT REPRINTS 81
ADVERTISERS INDEX 85
READER SERVICE CARDS 87

CAM CONTROLS PLANETARY GEAR . . . J Kaplan, Fairchild Camera
Incorporate this cam-planetary for wide variety of output motions 38

H-F CURRENT: STRONGER WELDS . . . R J Allen, New Rochelle Tool Corp
But welding above 60 cycles needs different techniques—here's how 42

HIGH-VOLTAGE HAZARDS IN INSTRUMENTS . . . F Lingel, General Electric Co
How to protect against shock and explosion possibilities 47

BUILDING-BLOCKS FOR LOGIC CIRCUITS . . . C F Meyer, Square D Co
A guide to designing circuits with transistor-type NORS 48

WHEN YOU NEED CHEAPER PROTOTYPES . . . E Konigsberg
Photo-story shows how—with 1-of-a-kind investment castings 55

CANTILEVER DEFLECTION-FACTORS . . . A Blake and L Scherff
Timesaver for beams under various types of loads 59

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS: **Elongation gives gage** for deterioration of rubbers 9
Performance of adhesives at ultralow temperatures 7
Ceramic coatings cure at 400 F, stand up to 3000 F 7

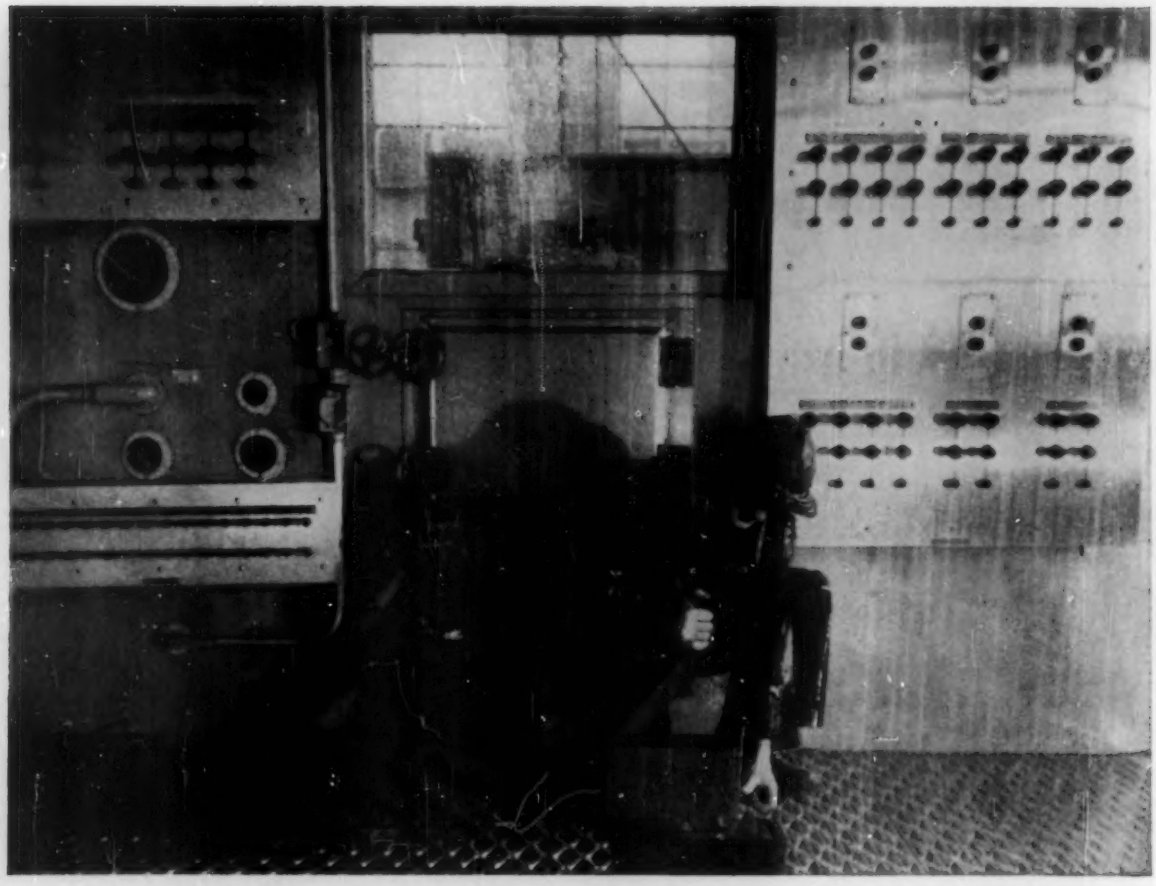
MECHANICAL: **Stepless adjustable-speed drive** comes as complete package 62
Combined analog-digital computer reaches breadboard stage 7
Sprag device transmits torque in both directions 16

ELECTRICAL: **Switch control** obeys temperature, time or pressure settings 62
Rotary switch governs power for automatic cycling 62
Radiant heating module has flameless infrared burner 8

OPTICAL: **Non-glare panel light** uses prisms to give subdued illumination 63
New microscope is held in the palm of your hand 9

PRODUCT DESIGN: **Centrifugal timer**—spinning weights—improves fuel control 45
Spot of light follows the workpiece 46
This space simulator floats on an air bearing 47

GENERAL: **Mobot the Robot**—our cover story 3
Tax treatment for research organizations may be revamped 13
Electronic facilities speed searching of technical literature 15



In test chambers of the U. S. Army...

Nickel meets the torture of man-made weather

Sometimes it's as steaming as the Malayan jungle...sometimes as hot as the Sahara...and then an arctic storm blows in. Nowhere in the world does Nature brew up such changeable weather as men do in Philadelphia.

Here in weather chambers of the U.S. Army, military equipment undergoes weather conditions that make Mother Nature seem like a gentle old soul by comparison.

If you think this is tough on the equipment, how about the chambers themselves. The equipment is in and out, but the chamber has to take it for test after test. That's why the designers line them with a Nickel Stainless Steel—Type 18-8. Nickel Stainless Steel *can* take it. It's corrosion resisting in the wettest atmosphere. It withstands sub-zero temperatures. The shocks of see-sawing "weather" conditions harm it not at all.

Still another Nickel alloy—a nickel-chromium type—lines heat test units where temperatures get up over 1200°F. Another nickel-chromium alloy is used for the glowing heating elements.

Make your own forecast of what a metal must face—Nickel and its alloys can help you meet the challenge. Is it ability to meet stress, fatigue, heat or cold, corrosive atmospheres or a combination of these? We may be able to help you find the answer in Nickel. Just write.

Weather chambers like this one designed by Tenney Engineering, Inc., Union, N. J., are lined with Nickel Stainless Steel. Notable installations include those at the U. S. Army's Frankford Arsenal, and Sperry Gyroscope Company, Long Island, N. Y.

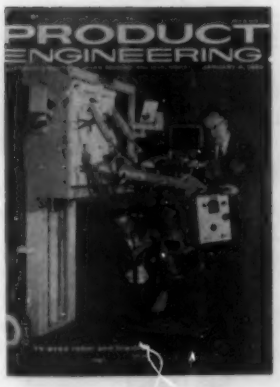
The International Nickel Company, Inc. INCO **67 Wall Street · New York 5, N. Y.**

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

INTERESTING TO NOTE

Mobot the Robot . . .



For centuries inventors have dreamed of building a mechanical man–a robot capable of following orders unquestionably, with the ability to "think for itself." Although no such creature has ever been built, there have been many valiant attempts. In fiction, robots have served man for ages. For example, H. G. Wells wrote of a mechanical-man kind of society, and French composer Dukas wrote a symphonic poem, "The Sorcerer's Apprentice," describing the drawbacks of having a robot assistant. On our cover, we show another type of robot assistant–Mobot Mark I. Although it can't think for itself, its mechanical hands can work with radioactive substances while being controlled from a booth several hundred feet away from the danger area. The machine was built by Hughes Aircraft Co for the Sandia Corp. The men pictured are Dr Allen E. Puckett (kneeling), Hughes vice-president and director of the company's systems development laboratories; and Robert W. Henderson, vice-president of Sandia Corp.

Recently, a scientist at Bell Telephone Laboratories, Dr Edward F. Moore, suggested a robot to top all robots. Moore's "mechanical object" would "live" on a beach and turn sand, seawater and salt air into useful products. Not only that, it would duplicate itself once a year. One problem, of course, would be our loss of beaches. In a year there would be only two machines nestled on a sandy beach, but in 35 years the machine population would be up to 32 billion. Then, with billions of machines lolling about, it would only be a matter of time before one learned to drive a car, and then . . .

Math + Logic = Boole

Programming a machine to do a predetermined job requires some system of logic (p 48). And one of the reasons we have so many types of "logic machines" is that there are so many different ways to approach a problem. Philosophers can fill a library with volumes on various schools of logic while mathematicians could fill another library with books on math. Yet, until the 19th century, very few philosophers or mathematicians could see an interrelationship between their two groups. George Boole was one of the few who did.

In 1831, at the age of 16, Englishman Boole became assistant master in a private school. By his mid-30s, he was professor of mathematics at Queen's College, Cork. It was then that the concept of marrying mathematics and symbolic logic stirred his imagination and prompted his writing a pamphlet, *Mathematical Analysis of Logic*. With the exception of Augustus de Morgan, Boole was probably the first English mathematician since John Wallis (1661-1703) to write about logic. Seven years

PRODUCT ENGINEERING

STANLEY J ALLING *publisher*
ELMER J TANGERMAN *editor*

ROBERT W CARSON *managing editor*
ROBERT E ABBOTT *senior associate editor*
RICHARD M KOFF *senior associate editor*

JOHN KOLB *associate editor*
NICHOLAS CHIRONIS *associate editor*
FORD PARK *associate editor*
ROBERT PRENTISS *associate editor*
ANNESTA R GARDNER *associate editor*
WILLIAM GILMAN *associate editor*
FRANKLIN D YEAPLE *associate editor*
JOSEPH J KELLEHER *associate editor*
DOUGLAS C GREENWOOD *associate editor*

BENEDICT A LEERBURGER, JR *assistant editor*
PHYLLIS B SWEED *assistant editor*
DORA K MERRIS *assistant editor*
HERBERT KEE *assistant editor*
CHARLES J LYNCH *assistant editor*
FREDERICK MARICH *assistant editor*
JOHN PRICE *assistant editor*

C C KANE *reader service manager*

FELIX GIORDANO *Detroit*
JACK MEYER *Los Angeles*
SETH PAYNE *Washington*

RICHARD E ROOMAN *art director*
E G LOADER *associate art director*
ANGELA M GIACIN *assistant art director*

NORMA J VAN NESS *production supervisor*
LILLIAN M WITHAM *assistant supervisor*

ROBERT E BRUCKNER *consulting editor*
DEXTER KEEZER *director, economics dept*

JOHN WILHELM *director News Bureaus*
MARGARET RALSTON *assistant*

GEORGE B BRYANT, JR *Washington*
DONALD MacDONALD *Detroit*
ARTHUR ZIMMERMAN *Cleveland*

STEWART W RAMSEY *Chicago*
JENNESS KEENE *San Francisco*
KEMP ANDERSON *Los Angeles*
RAY BLOOMBERG *Seattle*
B E BARNES *Atlanta*
MARVIN REID *Dallas*
JOHN TUNSTALL *London*
ARTHUR ERIKSON *Paris*
GENE DI RAIMONDO *Milan*
RAYMOND SHAH *Zurich*
CURT AGREN *Stockholm*
ROBERT GIBSON *Moscow*
MORRIE HELITZER *Bonn*
JIM MORRISON *Bonn*
SOL SANDERS *Tokyo*
JOHN YAMAGUCHI *Tokyo*

A McGRAW-HILL PUBLICATION

ABP ABC

January 4, 1960 Vol. 31, No. 1

PRODUCT ENGINEERING is published weekly — with an additional Design Digest issue in Mid-September, by McGraw-Hill Publishing Company, Inc, James H. McGraw (1860-1948), founder. PUBLICATION OFFICE, 99-129 North Broadway, Albany 1, NY. See Index to Advertisers for directions regarding subscription or change in address.

EXECUTIVE, EDITORIAL, CIRCULATION and ADVERTISING OFFICES: 330 W 42nd St, New York 36, NY. United States subscription rates for individuals in the field of the publication, $5 per year, single copies 50 cents; Canadian subscriptions $7 per year; foreign $25 per year, payable in advance. Second-class postage paid at Albany, NY, USA. © Copyright 1959 by McGraw-Hill Publishing Company, Inc. All rights reserved.

UNCONDITIONAL GUARANTEE. IF PRODUCT ENGINEERING'S editorial service becomes unsatisfactory for any reason, paid-up subscribers may cancel their subscription on request to our New York office and the proportionate subscription price of any unmailed copies will be refunded.

PRODUCT ENGINEERING articles are indexed in both the Applied Science and Technology Index and the Engineering Index. PRODUCT ENGINEERING publishes its own semi-annual index. Copies are obtainable on request to the editor.

POSTMASTER: Please send form 3579 to PRODUCT ENGINEERING, 330 W 42nd St, New York 36, NY.

later, Boole published a much larger work, *An Investigation of the Laws of Thought* . . . that contained the concept known today as Boolean algebra. Here, for the first time, a mathematician tried to show where any proportion involving a number of terms could be logically evaluated. This little-known work by an English schoolteacher is one of the earliest roots of binary computers.

Bikes Without Bounce . . .

When Charles Goodyear developed a successful way to vulcanize rubber he did a favor for bicycle manufacturers throughout the world. Bicycles quickly became popular, and boys eagerly took up riding their solid-rubber-wheeled bikes to school in favor of walking. But roads were poor and riding on that hard rubber left a lot to be desired. In Belfast, Ireland, in 1884, there was a small boy who pedaled to school every day. He complained to his father that riding was rough and the lad's father, Dr. John Dunlop, a veterinarian, decided to do something about it. He took a wooden disk wheel and fastened an inflated rubber tube around the edge of it. The tube was held in place with linen cloth tacked to the wheel.

To compare relative speeds of the new "air" tire and the old, Dunlop rolled both across his yard. The air-filled tire bounced off the side of the barn but the solid-rubber tire never even reached that building. Dunlop had invented the pneumatic tire just to please his son.

Although Dunlop developed his pneumatic tire before anybody ever heard of an automobile, the first cars used tires of solid rubber. These gave fairly satisfactory service in the era of slow cars and bumpy roads. When the first pneumatic auto tires were used, they gave a smoother ride but had trouble supporting a 3000-lb car.

Air was first used to support a vehicle less than a hundred years ago. Today, not only do millions of cars and bicycles depend on air, but a space simulator, described on page 47, is literally supported by a cushion of the same gaseous material. **—Benedict A Leerburger Jr**

SIDELIGHTS

Editors are not the hard, cold, mechanical critters some readers might imagine—and here's the proof. It was found in the file folder of an article on flame hardening published in *American Machinist* a short while back.

To flame harden, or not to flame harden—that is the
question.
Whether 'tis nobler in the shop to bear
The amps and volts of the induction coil,
Or to apply the flame directly to the part
And by heating harden it. To heat, to quench—
No more, and by a quench to say we end
The heat treat and the thousand thermal shocks
That steel is heir to. 'Tis a heating cycle
Devoutly to be wished. To heat, to quench,
To quench—perchance to crack. Aye, there's the rub,
For in that cracking what stresses may come
When we have finished this final quench
Must give us pause.—JACK DWYER

NEXT WEEK IN PRODUCT ENGINEERING

. . . Delivering the Message—Orally

First part of a seven-part series on oral reporting. General pointers on public speaking before a group of two or as chairman of a large meeting.

. . . Picture it with Perspective Grids

By using gridded sheets, perspective views become a practical pictorial tool.

. . . Fiberglass-reinforced Plastic Molded Parts

Here are 7 key processes out of the 15 now available. Their strong and weak points are explained.

. . . Low-melting-point Alloys

Included here are such design applications as special soldering, imbedding, glass-to-glass sealing, adjusting, casting and encapsulating.

. . . Critical Frequency of Stepped Shafts

This time-saving way to find the natural frequency adapts equation requiring only simple algebra.

How B&W JOB-MATCHED TUBING helps you design a better end product

You can get the right tube for your job with B&W Seamless Mechanical Tubing because you can choose from:

- ...a range of sizes, grades, and finishes for design flexibility
- ...a variety of heat treated conditions for the most suitable mechanical properties
- ...special shapes and prefabricated forms to improve design and simplify production.

These are just some of the reasons it pays to specify B&W Job-Matched Mechanical Tubing. Call your local B&W District Sales Specialist, or write for Bulletin TB-361 for full information. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

TA-9009-SM4

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

General Motors
announces
a new name
for its
Moraine Products
Division

DELCO MORAINE

BRAKE ASSEMBLIES • POWER BRAKES • BRAKE FLUIDS • BEARINGS • SINTERED METAL PARTS • FRICTION MATERIALS • DAYTON, OHIO

DEPENDABLY MADE

DEVELOPMENTS TO WATCH . . .

Performance of adhesives at ultralow temperatures . . .

. . . is being investigated by National Bureau of Standards for WADC. Tests thus far—at temperatures to −424 F—indicate that glass fiber-supported epoxy-phenolic compounds (used in lap joints on stainless steel) are superior to filled epoxides, rubber-phenolics and vinyl-phenolics (tested on 2024T-3 aluminum).

Samples were tested under tension after 10 min. or more at the test temperature and type of failure observed. Epoxy-phenolics generally failed by separation of the adhesive from the supporting glass cloth; while, with rubber-phenolics, failure was at the adherend interface.

At −424 F, the epoxy-phenolics showed an average ultimate tensile strength of 3120 psi; filled epoxides, 2345 psi; vinyl phenolics, 1650 psi; rubber-phenolics, 1065 psi.

Coatings that cure at 400 F but resist temperatures to 3000 F . . .

. . . are being developed under NASA sponsorship. These are ceramics (powdered quartz, cerium oxide, powdered mica), bonded with monoaluminum phosphate. In thicknesses of 0.003 in. or less they have good thermal shock resistance; even in heavy layers—to 0.020—they'll stand rapid heating to high temperature, though they can not endure repeated thermal shock by air cooling from temperatures above 1200 F.

Secret of the ability of the coatings to withstand high temperatures though they cure at low ones seems to be a chemical change which takes place on initial heating to high temperature.

The coatings are hard, glass-free and show good adhesion to the base metal. They have low thermal conductivity. They are, however, somewhat porous so they provide only limited oxidation protection.

In most of the tests, type 321 stainless steel served as the base metal; but screening tests indicate the coatings can also be applied to 1100-O aluminum, 1020 steel, and Inconel.

A combined analog and digital computer . . .

. . . is at the "breadboard" stage at NBS.

To take advantage of both types of computation, the machine divides numbers into two parts: a digital portion (x_D) representing the more significant part of a variable, and an analog part (x_A) in the form of an electrical voltage. The sum ($x = x_A + x_D$) then represents the full variable. Circuits for integrating and multiplying such a combined digital and analog quantity have been devised, and components (integrators, summers, multipliers) are being developed. These would be interconnected much as analog computer elements are now linked to solve a particular differential equation.

Advantages of the combination, Harold K. Skramstad of NBS told the Eastern Joint Computer Conference, include continuous indication of variables plus high speed and dynamic range. The new system should be most useful where required precision is about 10 to 100 times greater than that now obtainable by analog methods.

Stroboscopic revolution-counter . . .

. . . package-size and portable, has been developed by Mayer & Co KG, Neheim-Husten 2, Germany. An electro-optical device, it needs no connection to the device being monitored, and will determine speed and amplitude of motion as well as number of revolutions. Capacity is 200 to 15,000 rpm, in 3 ranges: 200-900, 900-3,600, 3,600-15,000.

In operation, a neon discharge tube produces a sharply focused red light which is beamed at the motor, generator, relay, circuit breaker, or other device being measured. The dial is then adjusted until the device "stands still," and the speed is read directly. The neon beam is bright enough, Mayer says, to permit clear evaluation even in bright daylight.

Called the Touro-Strob, it's designed for 240-v, 60-cycle ac operation. Power consumption is 25 to 35 w. It can also be used simply as a stroboscope with a maximum flashing frequency of 250 cps.

Electro-optical tachometer designed in Germany has neon light source, 3-range selector switch, and frequency-adjustment dial.

A radiant heating module, incorporating a flameless infrared burner . . .

. . . will soon be available for industrial heating equipment (plastics forming, metal drawing, paint drying, and the like) from Infrared Systems Inc, Riverdale, N. J.

Previous flameless heaters have used porous ceramic plates; in this one, gas is fed through a nickel-chromium alloy mesh which is the source of the infrared radiation.

An isotope altimeter . . .

. . . is being developed at Boeing Aircraft, and it's expected to be cheaper and more accurate at high levels than altimeters now available. At an altitude of 40,000 ft, the Boeing engineers say, a standard pressure altimeter shows an error on the order of 1200 ft; the new density altimeter should show no more than 200.

What the unit does is measure the "back-scatter" or reflection of beta particles by the atmosphere, a factor that is a function of atmospheric density and can be used to measure it. The device consists of a radioisotope beta-ray source, a probe, plastic scintillator detector, and photomultiplier, plus the usual amplifying and counting units.

The new device is considered as a supplement to, rather than a replacement for, the pressure altimeter. Boeing engineers believe the isotope device will be most suitable for use at altitudes above 25,000 ft, while the pressure altimeter still seems best for altitudes below 15,000 ft. Either should be acceptable between those altitudes.

A novel impact-detection system . . .

. . . is getting a tryout in Satellite Iota (Explorer VII). Its aim: measurement of micrometeorite impacts.

The instrument is surprisingly simple and effective. It's a cadmium sulfide photoconductor covered with an optically opaque film and connected to a resistance-measuring circuit. When a micrometeorite strikes the surface, it damages the film, permitting sunlight to reach the photoconductor. This lowers the cadmium sulfide's output resistance by a measurable amount, making it possible to count the impacts and obtain an indication of their size and force. Minimum size of particles that can be detected is about 10 micron dia.

Almost all steels with a Rockwell hardness of C30 or more . . .

. . . are susceptible to hydrogen embrittlement, say Naval Research Laboratory metallurgists after testing more than a dozen steels, including AISI 1020, cold-rolled austenetic manganese-chromium steel, 4340, 4130, 410, and several precipitation-hardening alloys. The first two (AISI 1020 and the manganese-chromium steel) showed only moderate susceptibility; but a 12% chromium hardenable stainless steel was particularly susceptible to attack.

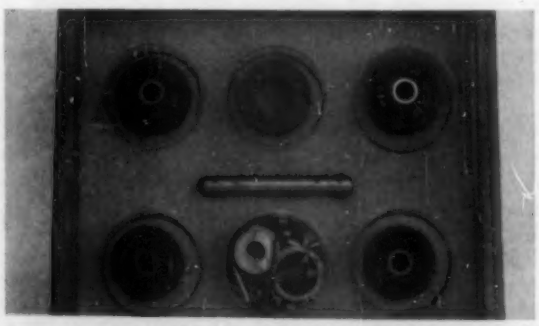
Nonferrous alloys, on the other hand, generally resisted hydrogen embrittlement; and the low alloy steels, in the lower hardness (below C30) did quite well, as did stainless type 304 at a hardness of C28.

The criterion used as an indication of embrittlement was the ratio of the lowest nominal stress at which a hydrogen-charged, notched tensile specimen fractured within 100 hr to the notched tensile strength of the uncharged material.

A report (NRL 5392) has been prepared and will be made available through OTS.

Miniature power drives . . .

. . . that might be used to operate typewriters, teleprinters, packaging machines, and the like have been developed by Tiltman Langley Ltd, Surrey, England, and the company is offering the components in kit form (see photo) for design use. Without tools, the company says, you can assemble a variety of clutches, backstops and hold-back dual drives (primary and secondary-driving a common output shaft). Nominal torque-handling ability of the clutch-free wheel-backstop combination is 20 lb-in. at 1500 rpm (½ hp). Maximum torque is 100 lb-in. Individual units are 1¼ in. dia and about ½ in. thick. Price of the complete kit is $56 (US equivalent), with individual assembled units priced at about $22.40 to $26.60. —ARG



Drive kit includes shaft, housings, control wheel, pawl, rollers, springs, pins, cam, and other parts needed for units like these.

WHAT'S HAPPENING IN RESEARCH . . .

Needed: new engineering systems for reactor shielding

External shielding is one of the most expensive features of reactor construction—and perhaps one of the least necessary. Its value seems to be more psychological than technical, says C. K. Beck of AEC's Hazards Evaluation Branch.

Says Beck, "it has been questioned whether the external 'vapor' containment building (the big steel sphere that serves as a barrier of last resort against releases of radioactivity) is really necessary . . . Thus far there has been essentially no occasion when external vapor containers have been called on to prevent release to the environment of what would otherwise have been damaging amounts of radioactivity."

The high cost of such containers makes such questioning increasingly urgent. But, says Beck, there remains an uneasiness, and a definite possibility, that safety devices will not operate as expected or that something has been overlooked."

For this reason, he believes "this barrier of last resort will remain as a feature of most reactors near populated areas for some time to come . . . The time may come within the next few years when there has been developed sufficient confidence in the engineering design and internal barriers to permit this final barrier to be omitted. But to accomplish this, the demonstration of dependability of engineering design, supported by actual experience, must substantially exceed what is now available before this step can be taken . . .

"However, imaginative new approaches to the plan of this external barrier, which could reduce its cost and make it perhaps a more effective safeguard, are entirely in order and are to be strongly encouraged."

Suggested alternates: controlled release and steam-suppression systems; both of which require a good deal of research and engineering; but both appear worth the effort.

New gage for aging of vulcanized rubber

The best gage for age-deterioration of vulcanized rubber is ultimate elongation, say Bureau of Standards researchers. Elongation of all vulcanizates decreases during storage; while tensile strength and modulus of elasticity may remain the same or even increase.

Synthetics generally get harder, while the change in natural varies. But tests on natural rubber and four synthetics (SBR, CR, NBR, and IIR) at temperatures from 75 to 250 F show ultimate elongation decreases in every one, and at a rather uniform rate of change.

While the change in elongation cannot be expressed in terms of simple mathematical equation, elongation does decrease approximately linearly with the square root of time; and for some vulcanizates at least, an estimate of storage life at room temperature can be made from measurements of ultimate elongation at two or more elevated temperatures.

brief . . .

More precise tensile, thrust compression, and weight measurement will be possible when two new deadweight machines go into operation at National Bureau of Standards. Now under construction, they're designed to extend the direct calibration range nearly 10 times. Present machines have a maximum weight capacity of 110,000 lb so equipment designed for higher ranges must be tested by a two-step method which compounds any measuring errors. The new machines will have capacities of 300,000 and 1,000,000 lb and will have temperature-control equipment to permit testing at any specified level from 50 to 100 F. —ARG

Hold this microscope in palm of your hand

A microscope that looks like a midget movie camera yet "yields an image identical with that of the largest conventional instruments" will soon be available in this country. Designed in Britain, it produces an erect image, provides for automatic focusing, and has built-in electric illumination (battery or cord). The manufacturer claims it is unusually sturdy and vibration resistant, and says it can be used for image projection on bench or screen.

Light enters the microscope from above, passes vertically downward through the condenser to the specimen and then to the upwardly directed objective. From that point, it is reflected horizontally along the base of the instrument and upward to the eyepiece. A selection of eyepieces provides for magnifications to 1425 X. US representative is Cooke, Troughton & Simms, Malden 48, Mass.

Hand-held microscope, claimed to equal conventional models in performance, is soon to be marketed in the US.

MICRO SWITCH Precision Switches

Precision switches to meet a wide variety of product design and plant use applications

MICRO SWITCH precision switches are important components in almost every type of electrically operated equipment—from delicate instruments to massive machine tools. They are installed on existing plant equipment to make operation safer, more automatic, and more productive. Shown here are but a few of the many thousands of MICRO SWITCH precision switch types which are famous throughout industry for utmost reliability, long-life, and precise operation.

Look for these features when you buy precision switches

Experience—MICRO SWITCH is a pioneer in the manufacture of precision snap-action switches to meet a wide variety of applications.

Quality—MICRO SWITCH products are laboratory-tested from raw materials to the finished product. Absolute reliability and uniformity of performance is assured.

Service—Experienced MICRO SWITCH Field Engineering Service is available from branch offices in key cities for consultation on switch problems.

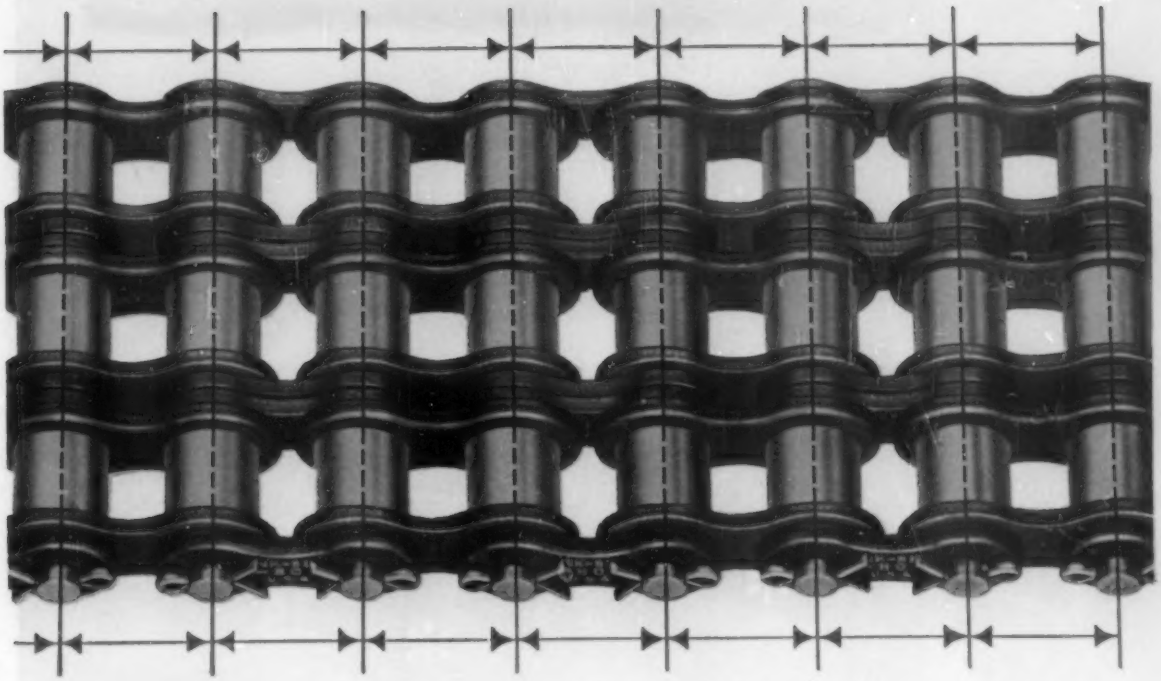
Development—MICRO SWITCH Engineering Service, if necessary, will cooperate in the development of an entirely new switch.

Replacement—MICRO SWITCH products for replacement or for installation on existing plant machinery are available from distributors in every industrial center. Look under "Switches, Electric" in the Yellow Pages.

Savings—Precise operation, long-life dependability, and freedom from maintenance of MICRO SWITCH products produce considerable savings of time and money.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches



Equal length... equal strength

How pre-stressing ensures uniform load distribution of multiple-width LINK-BELT roller chain

Pre-stressing is one of the reasons why Link-Belt multiple-width precision steel roller chains easily handle the grueling loads common on today's drives. It seats and cold works the chain joint parts, assuring equal load distribution across the chain, minimum initial elongation, increased fatigue life.

Pre-stressing is just one of many "extras" that contribute to the *greater dynamic strength* of Link-Belt roller chain. Others include: close heat-treat control, lock-type bushings, shot-peened rollers, pitch-hole preparation. For details see Book 2657.

PRE-STRESSING MACHINE provides the pull that "sets" the parts of Link-Belt multiple-width roller chain. Besides assuring uniform load distribution, pre-stressing eliminates application difficulties on fixed center drives because the chain leaves the factory at precise operational length.

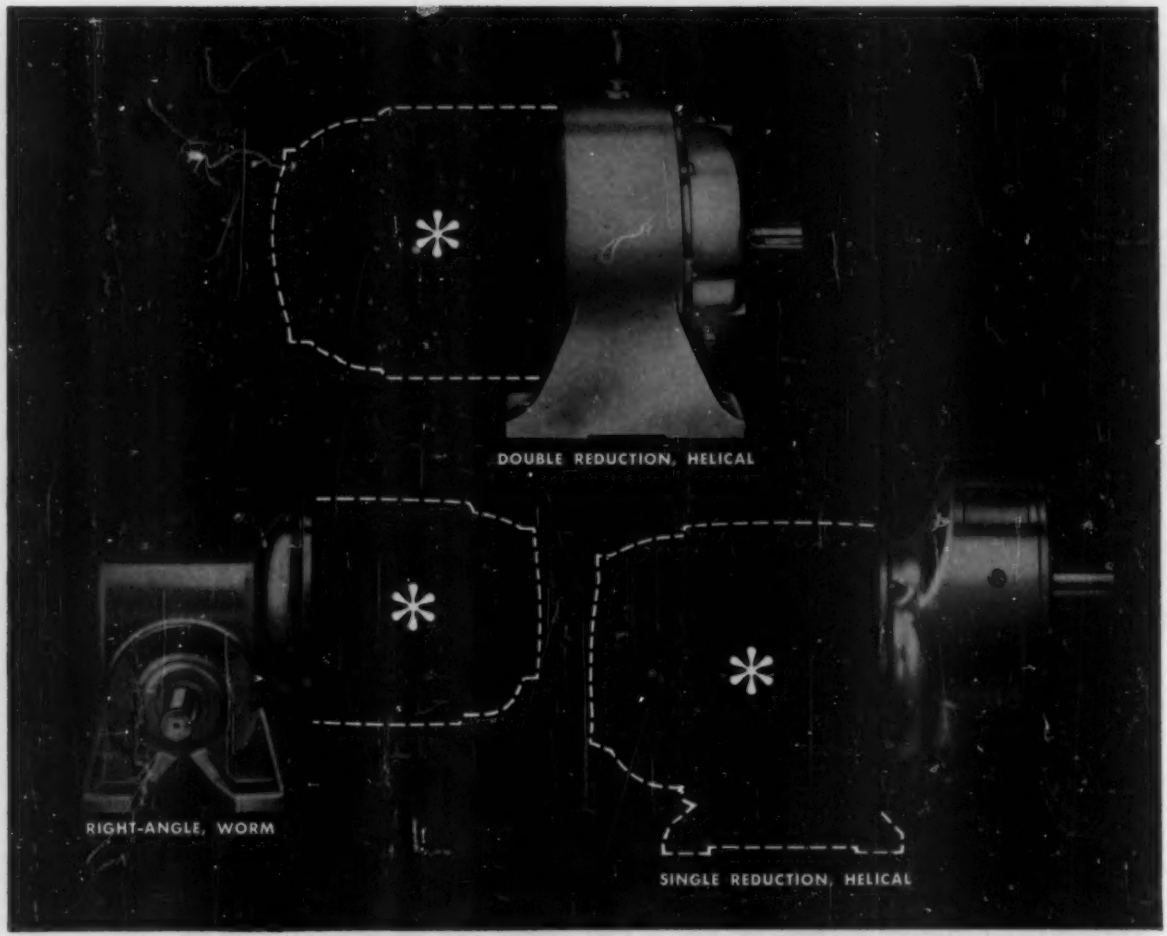
LINK-BELT

ROLLER CHAINS AND SPROCKETS

BOOK 2657 has 154 pages of roller chain data. Contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your classified phone directory.)

15.078

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.



Need a Motoreducer with an unusual drive motor?

LET REULAND TAILOR A MOTOREDUCER PACKAGE TO YOUR EXACT NEEDS...

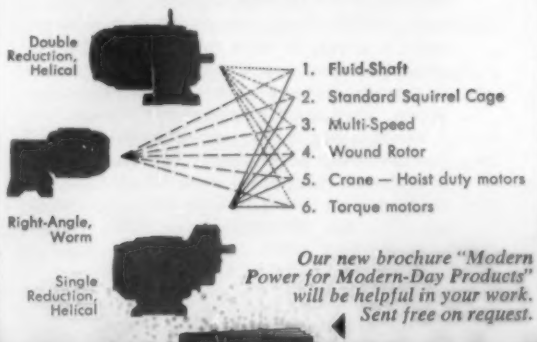
No longer must you "make something do"... no longer must you modify *your* machine to fit the *drive!* Hundreds of different speed and power variations can be developed from the three basic Reuland gear reduction units shown above.

This is made possible through the use of Reuland's famous "Xpandable-Design" idea.

Whether you need a simple motor-and-reducer — or an amazing, automatic combination with a special motor, gear reducer, magnetic brake and fluid coupling — Reuland engineers can quickly solve your drive problem.

Costs are lowered. Development time is saved. Your drive is *right*. Why not see first-hand what a Reuland Motoreducer can do for you.

*** ADD ANY ONE OF THESE 6 DRIVE MOTORS TO ANY OF THE 3 GEAR REDUCTION UNITS SHOWN ABOVE...**



Our new brochure "Modern Power for Modern-Day Products" will be helpful in your work. Sent free on request.

MODERN POWER FOR MODERN-DAY PRODUCTS
. . . ALL IN LIGHTWEIGHT ALUMINUM FRAMES!

REULAND MOTORS

Reuland Electric Company—Distributors in all principal cities
Western Division: Alhambra, California • **Eastern Division:** Howell, Michigan

A DEMONSTRATION UNIT FOR YOUR EQUIPMENT?

So sure are we you'll like what you see, we're offering to engineer a demonstration unit for your equipment without the slightest obligation. Just write us.

Refer to Sweet's Product File, Section 5a

FROM WASHINGTON . . .

The tax treatment for research organizations may be revamped

The House Ways and Means Committee has held one round of hearings on the matter, with further investigation certain.

Private research companies want the nonprofit labs to fork up with taxes too. At the Washington, DC hearings, Lewis E. Harris, president of Harris Laboratories of Lincoln, Neb, said the tax-exempt organizations such as Stanford Research Institute, Cornell Laboratories, Armour Research Foundation, Southwest Research Institute and some 60 others spread around the country were using their tax-free status to build up reserves for expansion while the private laboratories—burdened with the regular 52% corporation tax—are left hard up for funds.

Science has now reached the age of maturity and should be taxed like any other business, Harris told the committee. Harris labeled the tax-exempt research institutions as "economic leeches" and called on the congressional committee to end "the myth that science is a sacred cow."

The status of the tax-exempt organizations was defended. Norman Sugarman, Cleveland tax attorney and former official in the Internal Revenue Service, argued in support of the present law.

Key point in the congressional hearings centered on the definition of what is in the public interest and thus suitable for tax exemption. Harris insisted that publication of findings was the determining factor: If finds are not published, but held for the sole use of the sponsor, then the whole project should be taxed, he told the legislators.

Production of the product and not publication of research data is the deciding factor, Sugarman argued. And, as such, he maintained, sponsors of projects were entitled to get the jump on competitors. Otherwise, Sugarman argued, the research organizations would not attract private capital.

There is confusion about what the present law calls for on publication of research results. Committee Chairman Wilbur Mills (D-Ark) asked the witnesses what the present law required on publication of research results. But even the tax experts admitted that nobody knows. Some 30 years ago, the Internal Revenue Service ruled that tax-exempt researchers could restrict their findings for the exclusive use of sponsors. With the upsurge in research spending, however, this ruling is being challenged. The Treasury Dept has recently proposed a new rule that will require publication of results to qualify for tax exemptions unless the organization qualifies as an educational or charitable institution.

Further congressional hearings on the issue seem assured. But no date has been set.

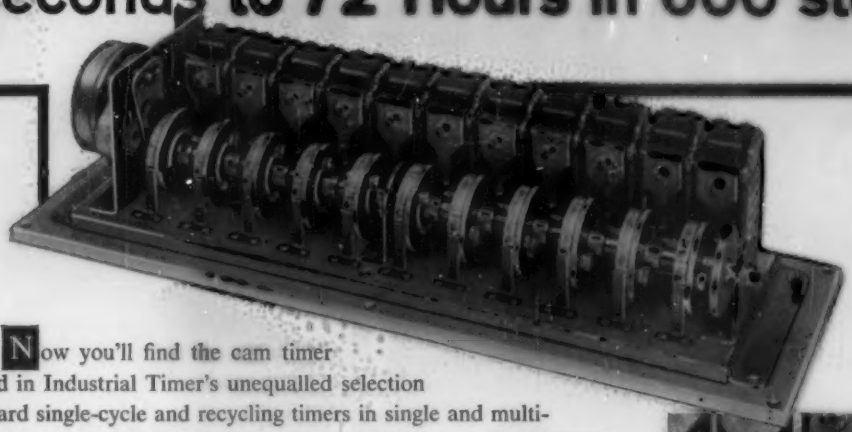
A congressional fight may erupt over the role of missiles vs aircraft

Defense cuts of late have mainly been made at the expense of aircraft. The rollback in the B-70 bomber program and trimming of production of the B-58 Hustler bomber are good examples. Earlier, the supersonic F-108 fighter was dropped.

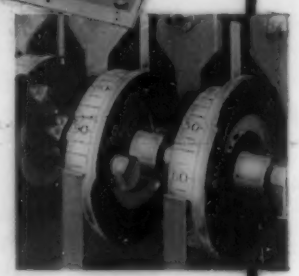
Reports are filtering out that top Air Force officers will make a plea for Congress to restore more money for aircraft. It will come when individual officers are called on to assess the military might of the nation—not as an official Air Force request. The B-70 is the only new-type plane under development, and its backers don't like to see the project downgraded.

THE WIDEST RANGE OF CAM TIMERS AND TIME CYCLES

2/3 Seconds to 72 Hours in 600 steps



Now you'll find the cam timer you need in Industrial Timer's unequalled selection of standard single-cycle and recycling timers in single and multi-switch types (up to 50 switches). Every model gives you 50 different overall time cycles, ranging from its lowest cycle up to 9 times that cycle. And standard cam construction lets you adjust ON and OFF periods from 2% to 98% of the total time cycle. Here is unsurpassed flexibility in cam timer selection and function.



If you don't find the timer you want in this unmatched range (a highly unlikely possibility), Industrial Timer's unique Timer Kit will help provide the exact timer you need at low cost. With this kit you can design your own prototype, and since the kit components are standard in our line we can reproduce your prototype—in quantity—*at no extra cost.*

For fast delivery on a standard or special Cam Timer check first with Industrial Timer. For more information ask for *Bulletin 200* Synchronous Motor Driven Cam Timers, *Bulletin 201* Multi-Cam Timer Kit, *Bulletin 202* Multi-Cam Switching Devices.

Industrial Timer's complete line of timers also includes: Time Delay Timers. Interval Timers, Running Time Meters, and Programmers. Bulletins describing these are available on request.

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

1409 McCARTER HIGHWAY, NEWARK 4, N. J.

Electronics Puts Speed into Searching of Tech Literature

CLEVELAND—Literature searching by machine took a giant step here Jan 1 when the American Society of Metals initiated a service which includes immediate information on any aspect of metal or metals engineering appearing in current world technical literature. Instituted at Western Reserve U's Center for Documentation and Communication Research, the project is supported by the Center and five other organizations: ASM, General Electric Co's Computer Dept, John Crerar Library, National Science Foundation, and the National Academy of Sciences-National Research Council.

Called the Metals Documentation Service and financed by ASM and NSF, the project offers a variety of programs tailored to needs of the individual metals man. They include:

- Current-awareness service—prompt, current information on a specific problem in the form of pertinent abstracts sent biweekly to subscribers. Cost: $12 per search, $300 for basic annual service.
- Generic searches—same current-awareness service plus searching on questions of wide interest. Example: fabrication of sandwich structures, use of oxygen in steel-making, and heat treating in controlled atmospheres. Expected large volume for generic searching results in lowered cost: $8 per search, $200 per year.
- Retrospective searches—preparation of bibliographies of previously published literature on any subject.
- Encoded tapes of the year's literature—available to those who operate their own searching machine. Integration of individual or confidential information which is not available in published literature.

AREAS OF DEVELOPMENT

Subject analysis of the desired document is accomplished by making a full and informative abstract which is then put into code so that every key word, every significant piece of data, and important relationship is available for machine searching.

A "semantic" code dictionary of scientific and technical terms permits abstracts of documents to be encoded so that words and phrases can be searched in terms of generic concepts. This means broadening the references that can be found by the searching machine in answer to a particular question. For example: code for "induction furnace" will permit a search for related subjects such as "electrical heating equipment," or even "heating."

A trial run of the service, confined to 10 customers but over a wide range of interests—research laboratories, metallurgical departments, company libraries, government departments and a university—was conducted successfully during 1959.

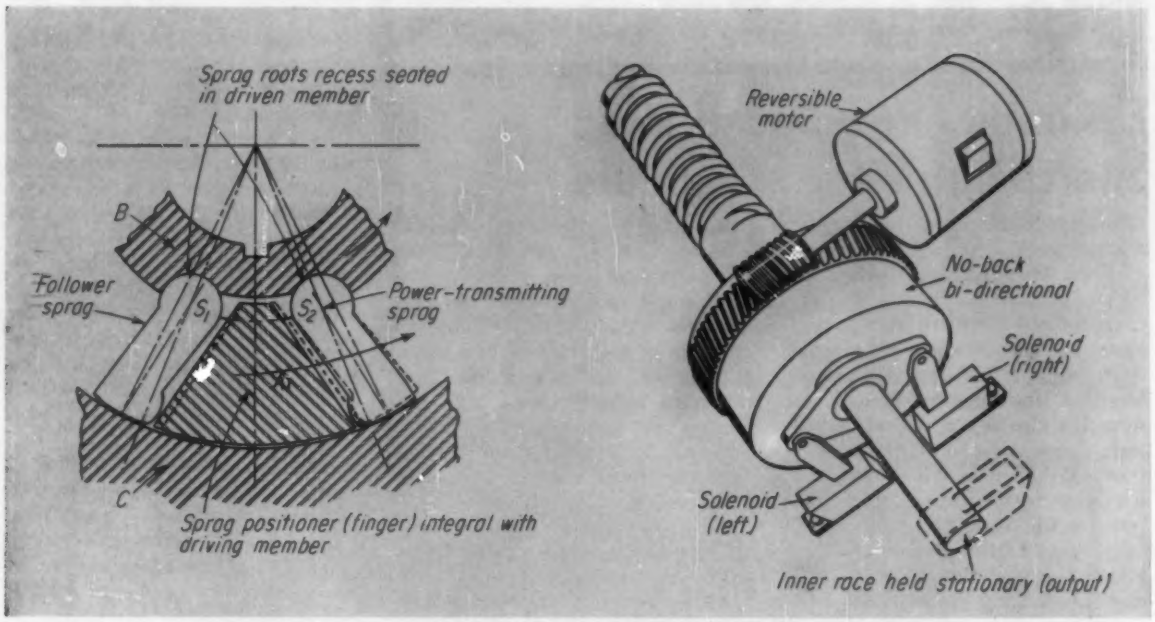
A typical question submitted during the test period was one asked by the government: what promising lines of research have been undertaken to overcome notch sensitivity of high-strength steel, and what avenues of research deserve further support? A literature search yielded sufficient material to give the government office a headstart on a complete answer.

Encouraged by the success of the trial run, NSF granted an additional $159,000 to extend the service into the related fields of solid-state physics, geology, mechanical engineering and inorganic chemistry—and to permit a thorough technical and economic evaluation of the service. Not only will conventional published literature be abstracted but also patents, dissertations, unclassified government reports and manufacturing literature.

Coverage of scientific and technical literature and other documents is expected to reach 40,000 items per year. Documents will be acquired by direct subscription and through a scanning service provided by the John Crerar Library. Documents will be analyzed by specialists at the Center, and "telegraphically" abstracted for encoding and machine searching.

Solicited from companies throughout the US and abroad, questions must be of a scope that is of interest to persons who have scientific, economic, or military reasons for desiring answers.—Allen Kent

INFORMATION-SEARCHING SELECTOR being built by General Electric Co will serve Metals Documentation Service offered at Western Reserve Univ's Center for Documentation and Communication Research. The GE-250 is a data processing system specifically designed to provide rapid inquiry and selection from large data files. Searching machine facilitates storage of information and of search questions; has the means for comparing such storage. It then detects desired information and records the result. Up to 10 questions may be prepared on punched paper tape and entered into GE-250's main memory for simultaneous processing. Successive reels of magnetic tape file are searched at a rate of 15,000 characters per sec servicing any or all 10 inquiries. Each tape may contain 6 million or more characters.



MOVEMENT OF FINGER offsets sprag cam section from outer race and transmits power from driving to driven member. Follower sprag slides against outer race and wedges if driven members attempt to drive.

POSITION DEVICE uses solenoid to disengage one set of sprags. Here, output member is stationary and outer race free to rotate in either direction, depending on which set of sprags is disengaged.

Sprag Device Transmits Torque in Both Directions

DETROIT—A new torque transmitter just developed by Formsprag Co promises a relatively simple and compact solution to design problems involving two-directional drives, backstopping, torque-locking, positioning or overrunning.

This new clutch is said to have high torque capacity, to eliminate all feedback from input shaft, and to function at high overrunning speeds. Sprags are arranged in two symmetrical pairs, (S_1, S_2). Each sprag is socketed in a half-round recess on the inner race. Fingers (A_1), on the driving member, prevent one set of sprags from engaging the outer race, (C).

Methods of mounting the clutch determine its function, but in all cases, it can transmit either clockwise or counterclockwise torque.

ANTI-FEEDBACK MOUNTING

One major application is preventing torque flow from the driven member to the driver. Here, torque input drives the fingers (A_1); output is at (B); and the outer race (C) is rigidly fixed. (Diagram above, left.)

Assuming counterclockwise rotation, fingers cause one set of sprags (S_2) to rotate slightly in their sockets so that their cam sections are clear of the outer race. Fingers then drive against the sprags (S_2) and transmit torque through them to the output member (B). Sprags (S_1) act as follower sprags here, their cam sections being in continuous sliding contact with the outer race. Any feedback (reverse) torque from the driven member (B) wedges sprags (S_1) against the rigid outer race, and is not transmitted to the driving member through the fingers (A_1).

DIRECTIONAL OVERRUNNING CLUTCH

To use the device as a two-directional overrunning clutch, Formsprag engineers suggest fixing member (B) against rotation; rotating member (A) slightly to disengage one set of sprags from fingers (A_1). The outer race is now free to rotate in one direction and lock in the other, direction of rotation being determined by which set of sprags has been disengaged. ■

Tires That Take Any Terrain

Huge tires designed by Goodyear Tire & Rubber Co find application on ground-support equipment for the Air Force's Matador missile. Called Terra-tires, they measure 42 in. high, 40 in. wide, 10 in. across the hub. Goodyear engineers report that Terra-tires deliver soft ride over virtually all types of terrain, and will prove valuable with earth-moving and heavy-construction equipment.

Tapping the Atom Boosts AEC Budget

WASHINGTON—Costs of operating the Atomic Energy Commission rose from $415 million in fiscal 1950 (June '49-May '50) to $2497 million in fiscal 1959, the Atomic Energy Commission's Annual Financial Report discloses.

Major expenditures of the past year are $511 million for reactor development and other research; $689 million for uranium-concentrate purchase; $713 million for production of nuclear materials; and $492 million for weapons development and fabrication. All these major areas except production of nuclear materials have dropped slightly since 1957 the AEC report disclosed.

BIGGER THAN GM

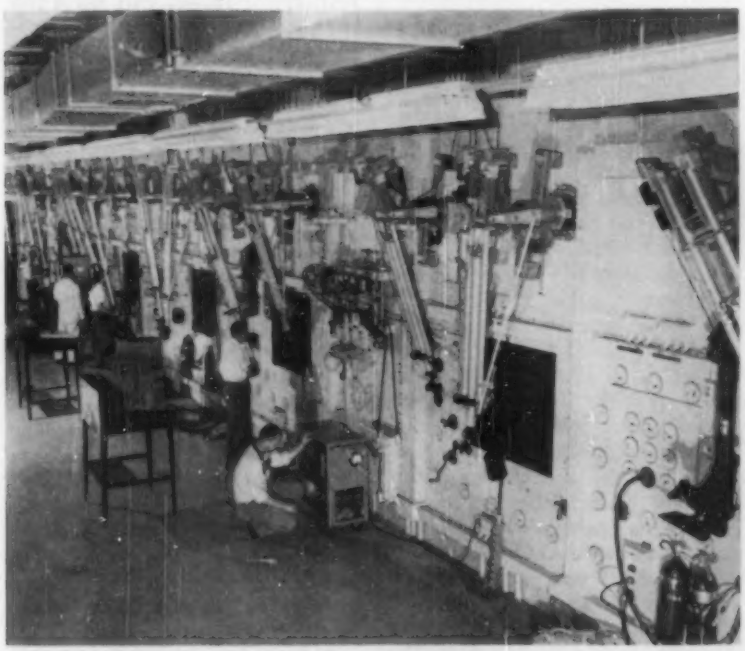
The commission further discloses that it now owns $7 billion of plant and equipment—$203 million was added in fiscal 1959. Another $250 million of construction is in progress. (General Motors plant and equipment—for comparison—is valued at $5.9 billion.) About $5.6 billion of this spending is for facilities to produce nuclear materials—$2.3 billion for gaseous-diffusion plants and $1.6 billion for production reactors and separation areas. Another $1.1 billion of plant is accounted for by R & D facilities, predominantly reactors and laboratories.

NEW REACTOR DEVELOPMENTS

To date the AEC has spent $1.6 billion on reactor development—$356 million of it last year. Emphasis is now on pressurized light water, sodium- and fluid-fuel reactors for civilian power; direct and liquid-cycle reactors for manned aircraft; project Rover for rocket propulsion; and ocean-going reactors for submarines and large ships.

Research is largely devoted to high-energy physics, controlled thermonuclear research and study of chemical properties and reactions. Also, considerable life-science study is being devoted to radiation standards for reactor-equipped subs and ships.

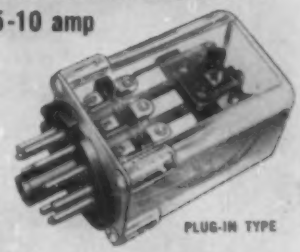
Remote Hands Speed Atomic Research



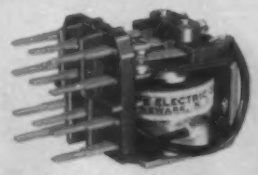
One of the most complex installations for handling radioactive materials is owned by Atomics International, a div of North American Aviation Inc. It is used for developing experimental atomic-reactor fuel elements and for testing various irradiated reactor materials and components. Milling machines, lathes and other equipment are located in the remote handling areas. Nine operating stations are equipped with shielded windows and mechanical arms. These remotely controlled manipulators, predecessors of "Mobot the Robot" shown on cover of this issue, are capable of threading a needle or of lifting up to 750 lb.

RELAYS with Golden Performance...

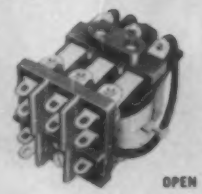
5-10 amp



PLUG-IN TYPE



PRINTED CIRCUIT TYPE



OPEN TYPE

Because each contact face is gold flashed you'll never have a corrosion problem with our Series MK General Purpose Relays. This gives them extended shelf life.

Furthermore, MK coils, custom made in our own plant are the finest available and set the standard for the industry.

Each MK Plug-in Relay is punch-card inspected and every relay is performance tested (150 times) before shipment.

All this means *reliability* in every sense of the word. Write today for our new catalog containing our complete line of relays. Mailed free on request.

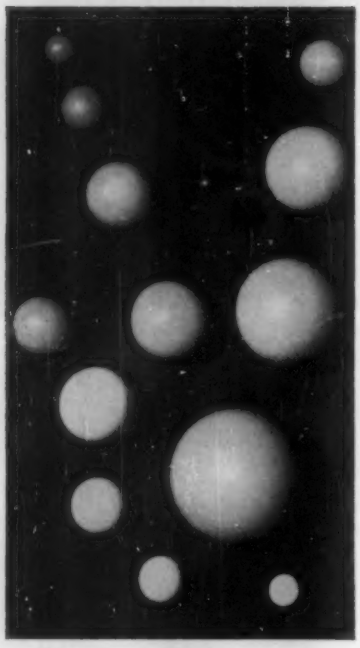
SERIES MK SPECIFICATIONS INCLUDE:
Up to 3 PDT in all types
Coil Resistance to 20K ohms/DC
Temperature ranges 45°C to 84°C (DC)
45°C to 55°C (AC)
Color-coded housings for plug-ins.

LINE ELECTRIC

LINE ELECTRIC COMPANY
271 SOUTH 6TH STREET
NEWARK, NEW JERSEY
AFFILIATE • INDUSTRIAL TIMER CORPORATION

CIRCLE 17 ON READER SERVICE CARD

CLEAN AND CLEAR BALLS



OF NYLON AND TEFLON

Because of improved grinding and finishing methods, ITI Nylon and Teflon balls are FREE OF EMBEDDED SURFACE GRIT. Their clean, clear finish assures THE BEST in performance for your products.

These balls are available in all sizes — standard (carried in stock) and special. Samples free on letterhead request.

Write **for prices and specifications.**

ITI
INDUSTRIAL TECTONICS, Inc.
MANUFACTURERS OF PRECISION BALLS AND BEARINGS
3675 Jackson Road, Ann Arbor, Michigan

Request for Waiver Points Up Differences in US Patent Policies

WASHINGTON—Contractors for the NASA, whose patent policies have become the center of a new congressional rumpus, have in recent months reported nine patentable inventions on projects sponsored by the government agency. Here's a rundown:

- Aero-Geo-Astro Corp, Alexandria, Va—a radar tracking beacon.
- Bell Aircraft Corp, Buffalo, NY—a rocket engine thrust chamber and a catalyst bed for rocket fuels.
- Northrop Corp's Nortronics Div, Hawthorne, Calif—a hypersonic-flow direction sensor.
- Chance Vought Aircraft Inc, Dallas, Tex—apparatus for a missile launcher; jettisoning system and rocket shrouds; coupling for the shaped charge of a destruct mechanism; and two separation devices for multi-stage rockets.

In all but two cases, NASA has taken title to the inventions without challenge from the contractors. Bell Aircraft, however, has petitioned the agency to waive the rights on the catalyst bed for rocket fuels; wants to apply for patent on its own.

Nortronics is also pushing for its own patent rights on the hypersonic flow-direction sensor. The company has challenged NASA's right to the invention since the invention was made on a project originally under a Defense Dept contract.

The Nortronics case plays up the difference between NASA and Defense Dept patent policies. On military R & D contracts, the contractor keeps title to the patent and has the right to get royalties on commercial production. But the military services are allowed a royalty-free, nonexclusive license to use the invention.

Last year's act establishing NASA set up a patent policy which falls between the Pentagon's liberal system and the restrictive AEC policy. AEC acquires rights and interests in all inventions of its contractors. On NASA contracts, the agency must take title or waive all rights. The agency cannot limit itself—the way the Pentagon does—simply to a free license.

The waiver, for which Bell has applied, can be issued under what industry critics describe as "cumbersome and uncertain procedures." So far, no waivers have been made on inventions developed under NASA contracts.

Final decision on both the Bell and Nortronics cases are still pending.

The space agency has already proposed a liberalization of its patent policy to Congress. The agency's idea is to provide for "discretionary" or flexible authority. This would give NASA a choice: to take clear title to the invention or to limit itself to licensing rights.

The outlook for liberalization is uncertain. Congressional Democrats —notably Sen Russell B. Long, chairman of the Senate Small Business Subcommittee on Monopoly, and Sen Joseph C. O'Mahoney, chairman of the Senate Judiciary Subcommittee on Patents—are starting a drive to prohibit patents to industrial contractors who develop inventions on government R & D contracts. ■

Military Men Hit Waste in Weapons Research

NEW YORK—Plain talk from military leaders about government's methods of channeling money for new armament marked the annual preparedness meeting held here by the American Ordnance Association.

Though severely limited by security restrictions, the Dept of Defense officers commented sharply on costs and unclear objectives of present-day research programming. They were members of a discussion panel assembled by the ordnance group dedicated to spurring military-industry cooperation in research, development and production of weapons systems.

One panelist, Rear Adm Paul D Stroop, Chief, Bureau of Naval Weapons, diagnosed the government's response to the challenge of our times as falling considerably short of good management: "We have diluted our efforts by starting too many programs and continuing some of them far too long."

Such waste can be rationalized by saying that the technical knowledge acquired from cancelled programs is not really lost, Adm Stroop conceded, but the cost far outweighs the value

of small gains. Experience, he went on, indicates that R & D costs much less than pilot-models and production stages. Waste would be reduced by following R & D with a thorough and objective evaluation of whether or not to continue the project through pilot stage.

We have further diluted our efforts, Adm Stroop charged, by starting, stopping, then restarting or drastically reorienting programs. Parallel programs should be carefully weighed as a means of speeding development because they are so expensive.

Lt Gen J. H. Hinrichs, Chief of Ordnance, US Army, told the meeting that a vital management problem at present is dividing funds between ordnance for general nuclear war and limited hostilities; between atomic and nonatomic weapons; and between rocket-missile and conventional types of weapons. At present the division is 70% rockets and missiles and 30% conventional weapons—a balance which Gen Hinrichs questioned.

With developments coming so fast, he continued, the military also faces the problem of being able to buy today's and tomorrow's weapons. The cost of preparedness will be bearable only if the military is very selective in its R & D programs. Sound progress, he concluded, depends on extensive development programs where components are developed before needed. ■

Manpower, Money Cramp UK Space Effort

LONDON — Britishers are getting involved in a new argument—how well is the nation planning for the Space Age? One bone of contention is a recent official report that found the country cannot afford the research required for space technology. Another is the charge that even if sufficient money did become available, it wouldn't do much good because technical manpower is lacking.

The money question was raised by a report from the Government Advisory Council on Scientific Policy. It declares that a national space program would be "grossest folly." It concludes that Britain can afford only a half million dollars annually in this field. In lieu of a national program, the Council proposes an international effort to which Britain and other countries could contribute.

The report was greeted with ridi-

NEW! THE WORLD'S FIRST HEAT RESISTANT 24K Acid Bright Gold

OROTHERM HT

HEAT RESISTANCE 5 ... 1100°c Minimum

CONTROL ONE ADDITION AGENT

TEMPERATURE RANGE 65°F to 115°F

BRIGHTNESS MIRROR

OPERATION BARREL or TANK

For complete information on OROTHERM HT Write, Wire, Phone or TWX

Technic inc ST 1-6100

P.O. BOX 965 PROVIDENCE, R. I.
7001 NO. CLARK ST. CHICAGO 26 ILL

CIRCLE 204 ON READER SERVICE CARD

VIKING LIQUID ABRASIVE PUMPS
NOW LAST LONGER

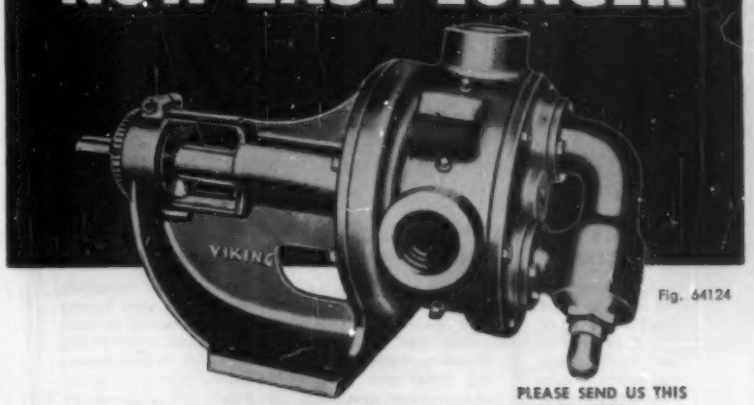


Fig. 64124

Now, you can double or triple pump life with this new heavy-duty Viking. Specially designed with ceramic bearings and mechanical seals to pump paints, inks and other *abrasive liquids. Field tested and proved, pumping liquids from 100 S.S.U. to the heaviest viscous types . . . G.P.M. sizes 3, 6, 12, 16, 25, 40. Let us help you solve your problem.

* Consult factory for recommendations on pumping abrasive liquids other than paints or inks.

PLEASE SEND US THIS INFORMATION:
- Liquid to be pumped
- Viscosity of liquid (S.S.U.)
- Percentage and type of solids present in liquid
- Temperature of liquid
- Specific gravity
- Capacity of pump needed
- Suction lift or head
- Discharge pressure

AND ASK FOR BULLETIN SP-507X

VIKING PUMP COMPANY
Cedar Falls, Iowa, U.S.A. In Canada, It's "ROTO-KING" Pumps

See Our Catalog in Sweet's Product Design File

Cover exposed ends of screws, rods, studs, wire with

ACORN PALNUT® FASTENERS

- Reduce assembly parts, operations, time and cost
- Provide vibration-proof assemblies
- Low in cost
- Protect against scratching
- Add pleasing appearance.

3 TYPES AVAILABLE to meet design needs

1 ACORNS that turn on screw threads

ACORN PALNUT LOCK NUTS

Attractive spring steel lock nuts apply fast with hand or power tools. Save weight and cost, stay tight in service. Full acorn and semi-acorn types. Many sizes and finishes, #6-32 thru ⅝"-16.

2 ACORNS that push on plain rod

ACORN PUSHNUTS®

Simply push on unthreaded rod or wire for tight assemblies. Strong spring steel grip. Save threading, drilling, grooving, cotter pins. Closed and open end types. Sizes for .120" to .312" dia. rod in choice of finishes.

3 ACORNS that make their own threads

ACORN PALNUT SELF-THREADING NUTS

Save cost of threading. Make their own threads while tightening on plain rods, studs or wire. Fast assembly with standard tools. Vibration-proof. Removable and reusable. Sizes for ⅛" and 3/16" dia.

WRITE for free samples and data. State type, size and application.

PALNUT®

THE PALNUT COMPANY
Division of UNITED-CARR Fastener Corp.
65 Glen Road, Mountainside, N. J.
Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

LOCK NUTS and FASTENERS

cule. Critics pointed out that the proposed expenditure is less than half the government subsidy for the Covent Garden Opera Company and far less than the $38 million paid to farmers for chicken food or the $2.5 million of taxpayer money spent to advertise the government's egg-selling program.

Defenders of the report retort that the recommendations are not far out of line with research support in other areas. The government awards only $27 million annually to industrial research and $10 million to medical studies. (British industry does relatively little research compared with the US. It is said that R & D of 35 US companies with subsidiaries in Britain exceeds that of all British industry combined.)

A second government report, on the personnel problem, also appeared recently. It says that the acute shortage of scientific and engineering manpower is growing worse. Unfilled vacancies now exceed 6000 and more are opening up. The shortage of teachers in mathematics, physics and chemistry is the most serious deficiency of current training programs, the report adds.

Manpower policy has also drawn fire from B. V. Bowden, principal of one of Britain's leading technical colleges. He cites a 28-nation survey which shows that Britain's university population ranks third lowest in percent of total population. The survey illustrates the nation's resistance to technological education, he charges, and is another sign of British education's failure to adapt itself to the needs of modern industrial life. ■

AMA Urges Engineers to Update Concepts

NEW YORK—Automation is the latest triumph of a long technical evolution in US industry. And, as it becomes more deeply entrenched, product designers will have to change traditional concepts of reliability, versatility and variety. This prediction was offered by Robert E. Schmeck, assistant to the chief development engineer of Pitney-Bowes Corp, in an address before the Product Design and Development Forum of the American Management Association.

Schmeck spelled it out this way: Every industry will feel the effects of these "intelligent" machines that re-

member and make decisions; product obsolescence will accelerate even in industries remote from the new technology; even manufacturers of account books for family budget records may soon find their market swept away by inexpensive electronic accounting machines that tie directly with a bank computer.

His own company, Schmeck said, has been forced to add two major product lines—check sorters and mail sorters—to counteract the threat of shrinking product markets. There is a trend toward designing products with a future built into them, he continued. With these versatile products, the consumer can buy basic equipment, then add to it as size of business and finances permit. Pitney-Bowes check sorters, Schmeck explained, are built up from modules. Each installation can be adapted to floor space of the customer's facility or expanded with work load. Such design requires that each module be an independent entity with its own power source.

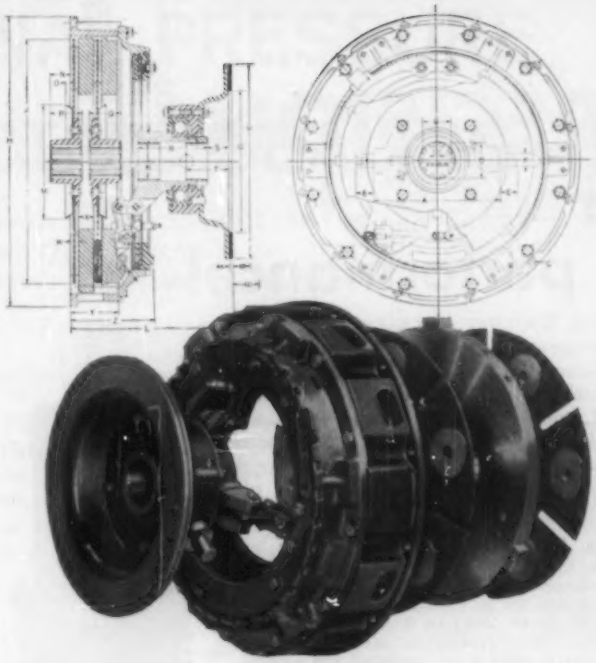
ORDER CAR FROM CATALOG

A trend toward greater reliability is also certain, he predicted. The general public will hear of missiles with absolute reliability, and will demand the same in their household appliances. Because most product failures today derive from components of cheap materials included to cut costs, Schmeck said, future appliances and autos will doubtless be made of quality materials and increased costs will be offset by more automation in manufacturing.

Greater variety and personal choice in design of consumer products is also in the offing, he said. Conceivably, the auto buyer will eventually walk into the salesroom and chose major components of his car such as body style and color, transmission, and brakes from a catalog. His order will be put together from stocks at the assembly plant and delivered to him.

The advent of automation will require great changes in the management of engineering, he concluded. All divisions concerned with products will have to be involved in design from the beginning. Too often now, a product moves from research to advanced engineering, to product design, to marketing and sales in a sequential manner. If any division along the line has objections, it kicks

ROCKFORD



Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

Greater Power With Less Size from a DOUBLE PLATE Clutch

This Heavy-Duty ROCKFORD Morlife CLUTCH, used in a large crawler-type tractor, provides more torque capacity than previous clutches of the same diameter. More service life and more heat resistance makes this clutch perfect for all heavy-duty type machines. A heavy-duty brake plate is mounted on the ball bearing type release sleeve. If you have a heavy-duty vehicle in the planning stage, it will pay you to learn about these and other advantages of this new clutch—before you design the drive line. A design study of your present drive lines might indicate advantages of using this Heavy-Duty ROCKFORD CLUTCH.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

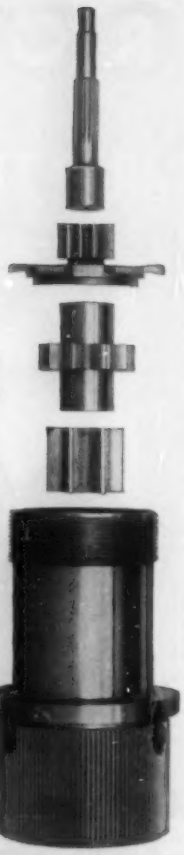
209 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

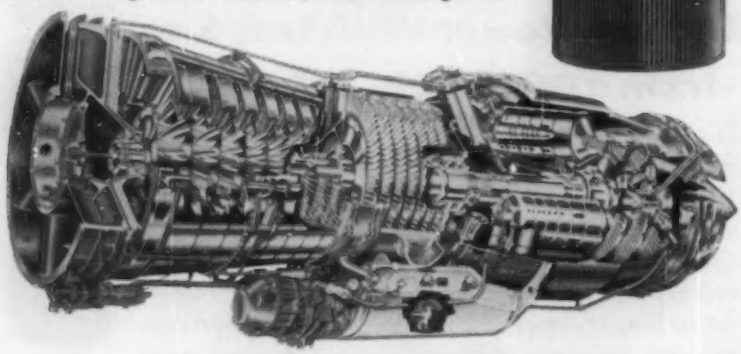
CLUTCHES

PRECISION for top-flight performance!



Rigid PRATT & WHITNEY AIRCRAFT precision requirements spell *performance* . . . top-flight performance. Reason: The future is at stake. And that future can well ride on gear teeth. Since 1940, PRATT & WHITNEY AIRCRAFT gear tolerances have been *Perkins'* standards . . . for commercial gears as well as aircraft. Such precision pays off in longer wear, greater efficiency, lower maintenance cost. That type of precision can pay off for you, too.

Famous PRATT & WHITNEY AIRCRAFT J57 Jet Engine, power plant for Air Force "Snark" guided missile, is geared for both commercial and military performance by *Perkins*. Typical tolerances on *Perkins* gears: .0004 tooth to tooth; .0015 cumulative; .0005 on involute. On spline: .0006 tooth to tooth; .0008 cumulative; .0005 on involute. Most *Perkins* gears are carburized, hardened and ground.



YOURS ON REQUEST
Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

PERKINS
MACHINE AND GEAR CO.

Dept. 62 West Springfield, Mass.
Telephone: REpublic 7-4751

the product back to the preceding department. This autonomy of department responsibility is too cumbersome for complex products of automation. Mr Schmeck expects engineers to bear more responsibility for foreseeing sales possibilities. The engineer will have to assist the market researcher who is presently hard put to measure markets for products that have never existed before.

DESIGN ENGINEER IS "HOW" MAN

An appraisal of the design engineer and his job was given to the AMA by Elmer Tangerman, editor of PRODUCT ENGINEERING. The design engineer, he said, is the "how" man in the middle who must take new ideas and convert them into product designs that will sell. Because he bears heavy responsibility for designing products at practical cost in his present plant, he is constantly searching for flaws and faults. His job requirements tend to make him a "no" man and a relatively poor source of new-product ideas. Tangerman quoted a survey of 80 companies by Booz, Allen & Hamilton which shows that 50% of new-product ideas come from marketing, 20% from engineering and 30% from miscellaneous sources.

Creativity is a delicate quality that management is relentlessly seeking in its scientists and engineers. Discussion from the floor after Tangerman's presentation bore testimony to universal concern with this quality. Heated debate concentrated on such questions as: How can a manager identify creative people? How can he best give them assignments? How can he measure what they are doing? Should creative people be concentrated in a single department or scattered throughout the company?

A third speaker, F. Walter Perl, director of styling for Westinghouse, told the AMA that styling is a great stimulus to sales. And, he said, Westinghouse now has a variety of designs in the lab that are styled for life today. These include thermoelectric refrigerators and freezers that can be used for room dividers and low washer-dryer combinations for the bathroom. The reasoning behind bathroom laundries is that dirty clothes today originate upstairs. Dish washers and plastic coverings for tables have eliminated dirty clothes downstairs. ■

INTERNAL PRESSURE VS. EFFECTIVE SEALING

Internal pressure creates two forces which can cause leakage in a gasketed joint. Proper flange design and correct selection of gasket materials can overcome these forces.

E. M. SMOLEY,
Research Physicist
Armstrong Research and Development Center

The pressure of confined liquids or gases acts against a gasket in two ways, as shown in figure 1.

1. Hydrostatic end force. This is proportional to the internal pressure and

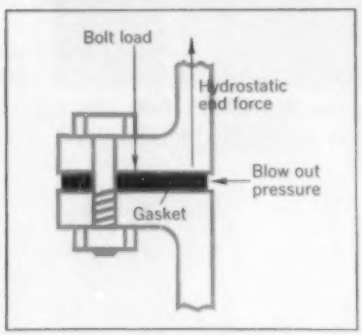


Figure 1. How internal pressure acts on a gasketed joint.

tends to move the flanges apart. As this occurs, the load on the gasket is reduced and leakage can result.

2. Blowout pressure. The sealed liquid or gas exerts direct pressure on

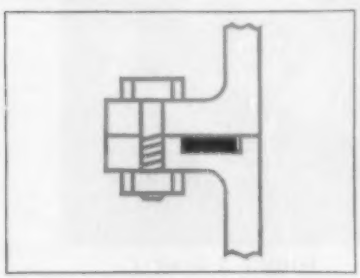


Figure 2. Flange design which confines gasket helps minimize blowout pressure.

the inside perimeter of the gasket. If this pressure is high enough, it will force the gasket out of the joint and leaks will occur.

These forces are usually associated with relatively high internal pressures. Studies at Armstrong Research and Development Center show, however, that pressures substantially less than 100 psi can cause leakage in some assemblies. (The Deflectometer shown in figure 3 is one tool used by Armstrong research engineers to measure flange deflection caused by internal pressure.)

Where internal pressures are involved, it is especially important to consider the joint as a unit. The flange design, the gasket material, and the temperature at the gasket line should all be considered in relation to each other.

The obvious first step is to be sure that flanges are sufficiently rigid to impose the required unit load on the gasket. The number of bolts, their size, their spacing, and their torque values are other factors related to flange loading which must be considered.

The second step is the evaluation of the gasket material to be used. High unit loads dictate the choice of a material that will not extrude or rupture under high pressures. This usually means a dense cellulose fiber or asbestos fiber material.

Several compositions suitable for service under high flange loads are available in the Armstrong Accopac line of beater-saturated gasket materials.

Where a compressible material such as cork-and-rubber is to be used, a flange design which confines the gasket,

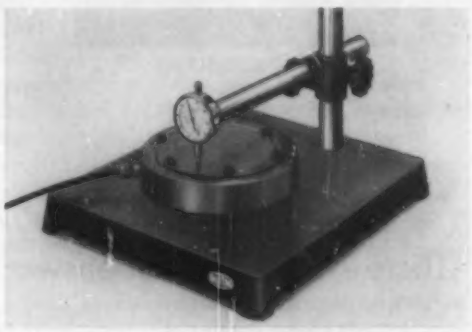


Figure 3. This Armstrong developed Deflectometer measures effect of 70 psi internal pressure in this stamped flange. Leak-producing deflections of .007" were detected at center point between bolts.

as in figure 2, will also help overcome blowout pressure.

A more complete discussion on the effect of internal pressure and other problems of gasket design, selection, and performance is included in the Armstrong Gasket Design Manual. Write today for your copy of this 32-page book. Address Armstrong Cork Company, Industrial Division, 7101 Irvin Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

1860–1960 Beginning our second century of progress

POINTS OF VIEW

THE QUESTION: *Should a company*

H S EBERHARD
President
Caterpillar Tractor Co

"The government is a special type . . .

of customer. We must employ procedures quite different from our regular commercial business. When bids are requested, specifications must be analyzed for modifications, or special attachments or versions. Prices must be established for nonstandard items. We must decide if we can do the job. Once a contract has been received it must be interpreted in terms of work and engineering orders; billing and shipping procedures must be set; service publications must be prepared. The purchaser will inspect the products during manufacture to insure quality requirements are met. This can be handled most efficiently by a separate department.

"Our Defense Products group, with its own engineering staff, is able to keep abreast of the many special conditions of defense work. This insures a continuity of understanding and experience within the group, and a familiarization with the military agencies and their particular activities. This allows us to analyze defense requirements more quickly and to find our role in the over-all programs.

"With this continuing attention to detail, both the company and the government benefit. The result is the ability to provide products that the military needs, to keep up with long-term programs, to assist with research and development, and to provide these services at a minimum cost."

"There is no universal answer . . .

to this question. How a company can organize most effectively for defense work depends upon a number of factors—size of the company, the extent to which it participates or plans to participate in defense work, the field of activity, inherent characteristics of the company—just to name a few. Therefore, the answer must be qualified in terms of applicability to a specific company or type of company.

"One point I would like to emphasize, however, is that a decision to organize a separate group to handle a company's defense work must contemplate that this group will be so integrated that full support of the company's resources is assured.

"We at Chrysler undertook, more than five years ago, the establishment of a separate organization designed expressly to meet the requirements of the military and government agencies. Today this organization, The Chrysler Defense Group, consists of two major operating divisions—a Defense Operations Division and a Missile Division—as well as a technical planning staff known as the Advanced Projects Organization.

"The divisions have responsibilities in the areas of development and engineering as well as production, supply and logistic support. Each is directly responsible for the operation and management of the laboratories and plants in which its products are developed and produced. The Advanced Projects staff has a long-range mission directed toward meeting the challenges of tomorrow. Our Defense Group is nevertheless an integral coordinated part of the whole of Chrysler Corporation. This assures the military and government agencies of the full support of our total corporate resources and strength."

IRVING J MINETT
Group executive
Missile and Defense Operations Div
Chrysler Corp

have a separate department to handle defense work?

R E McDONALD
Manager, military div
Remington Rand Univac

"The most obvious advantage . . .

of such an operation is the fact that security regulations can be administered and enforced with far greater ease and effectiveness than otherwise. It is easy to anticipate the many problems that would arise in observing rigid security codes while simultaneously engaging in military and nonmilitary programs. It would be necessary either to set up a 'double standard' for security—one set of rules for military programs and another for commercial programs—or to impose rigid security regulations on both groups, encumbering nonmilitary personnel and facilities with an unnecessary burden.

"Maintenance of extremely high standards of reliability is a factor of paramount importance. The need for ultrareliability in military systems places unusually severe demands on personnel and facilities. In all areas—materials procurement, personnel, design, production, inspection—special routines and techniques must be employed to achieve the extraordinary degree of reliability required. Again, it would be necessary to maintain two systems of operation if we attempted to absorb military programs into a commercially oriented organization.

"This is not to suggest that Remington Rand is less mindful of reliability in its commercial systems. However, it is generally understood that ultrareliability in military systems imposes what might be termed 'cruel and unusual' standards. The same degree of reliability is not only unnecessary in most commercial processes, but also would push the price of a commercial system beyond all practicable limits.

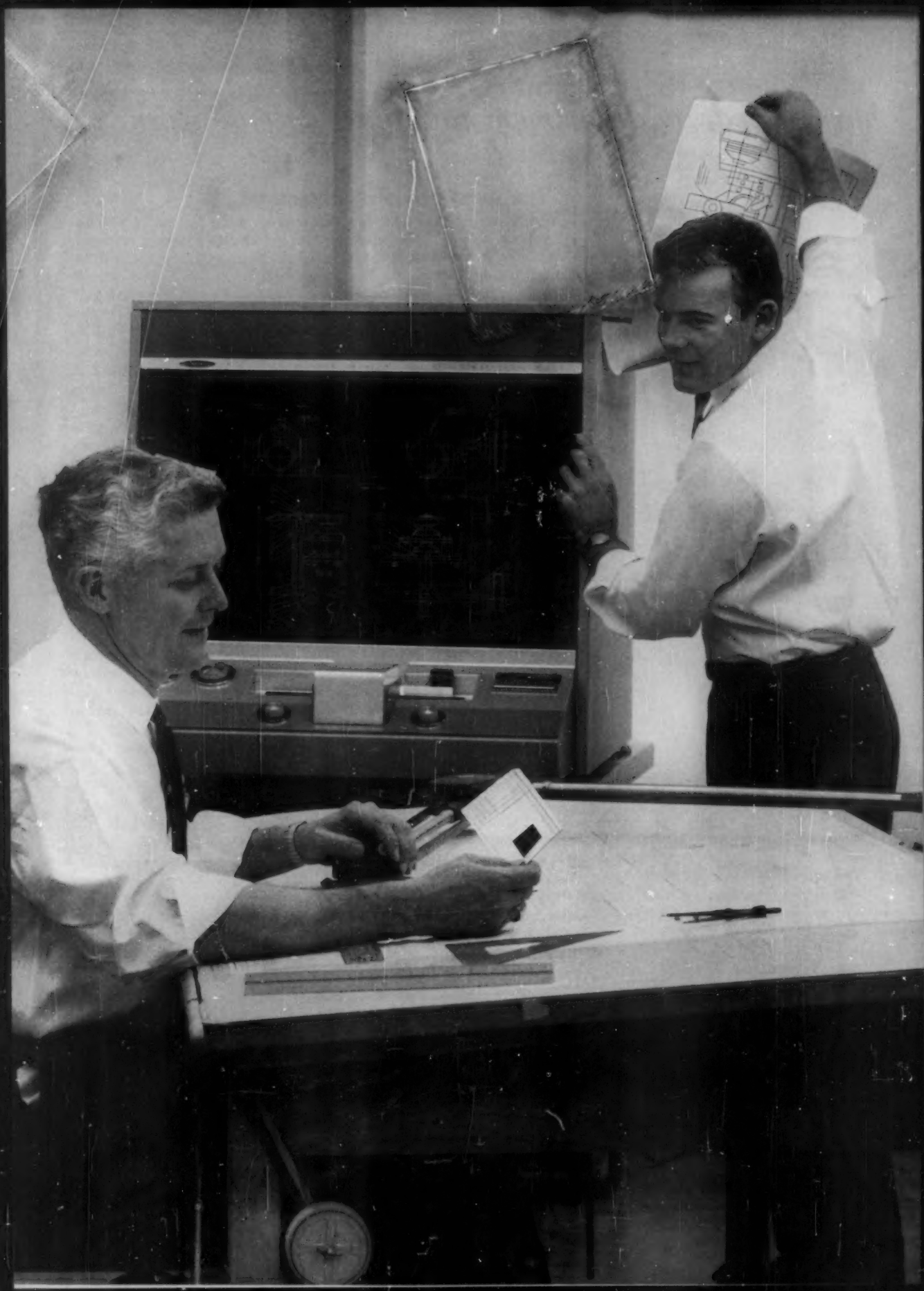
"It should be noted, however, that many of the concepts and techniques which the company has developed in its military programs have application to commercial systems. In this way, the frontiers forced by military development are greatly increasing the capabilities of nonmilitary equipment. Perhaps one of the chief advantages of a separate military division is the fact that such an operation can move with speed and agility."

"It's not possible . . .

to answer this question with a single statement that would be applicable to all companies doing defense work. For example, a company selling a regular line product that has application in the military field could very possibly operate efficiently without a special 'defense' department. A company manufacturing a product that has been slightly redesigned could enjoy a considerable volume of business from this product and do so efficiently without a special 'defense' department. On the other hand, a company such as ours, doing a considerable volume of defense business, business that includes concept work, design engineering and manufacturing production, finds it not only desirable but advantageous to have a specific organization geared to handle this type of business and to handle it on an exclusive basis.

"Engineers who understand and design products in keeping with military standards, procurement people acquainted with military purchasing procedures, accountants who know military auditing policies, all provide cost-saving advantages on defense contract work, ultimately saving taxpayer dollars. In the case of Food Machinery and Chemical Corp, because of the type of defense material produced and the volume of this business, management deems it sound judgment to handle this business through a separate division of the company."

JAMES M HAIT
Executive vice president
Food Machinery and
Chemical Corp



now... 3M makes microfilm so easy to use

■ Each month more and more companies are turning to microfilm for engineering drawing reference systems. The advantages are many—greater security plus considerable savings in manhours, materials and reproduction costs. But, the most important reason is that 3M's new THERMO-FAX "Filmac 200" Reader-Printer now makes microfilm so practical—so easy to use. ■ The "Filmac 200" Reader-Printer combines the advantages of a reader and a printer in a single low-cost unit. You can refer to the enlarged drawing clearly projected on the big viewing screen, and make a work-size print in seconds. You can take more than a look—you can take a copy. The time savings are obvious. ■ The THERMO-FAX "Filmac 200" Reader-Printer lets you make copies of what you need when you need them. So low in cost, it puts microfilm in reach of even the smallest engineering firm or department. ■ If you are now using microfilm for your engineering drawings you will find that the "Filmac 200" Reader-Printer will fit into your present reproduction system perfectly. Engineers save valuable time—in seconds your reproduction department can make enlarged prints for them—or they can even make their own. ■ If you are considering microfilm for engineering drawings, investigate the "Filmac 200" Reader-Printer first. Its low initial cost and low operating cost—plus its fast and simple operation—make the microfilm reference system practical and so easy to use. ■ Call your local dealer or mail the coupon now for complete information.

Thermo-Fax "Filmac" Reader-Printers

3M COMPANY

THE TERM "THERMO-FAX" IS A REGISTERED TRADEMARK OF 3M COMPANY

Minnesota Mining and Manufacturing Company
Dept.FBN-140,St. Paul 6, Minnesota
Please send me complete facts on the new THERMO-FAX "Filmac 200" Reader-Printer.

Name_____
Title_____
Company_____
Address_____
City_____ Zone___ State_____

MINNESOTA MINING AND MANUFACTURING COMPANY
St. Paul 6, Minn.
...WHERE RESEARCH IS THE KEY TO TOMORROW

CIRCLE 27 ON READER SERVICE CARD

PACKED Full Of FACTS

on

SILVER BRAZING with PREFORMS

Now . . . in one complete 16 page booklet all the latest information on how to increase production, save time with brazing preforms.

- Complete information on NO-TANGLE NOTCH COIL RINGS — how they provide new efficiency and new economies in handling alloys.
- Helps you select the proper PREFORM for the job. Contains charts that illustrate the type joint, recommended PREFORM and simple ordering data.
- Gives the complete line of EDGEWOUND AND BLANKED WASHERS, and silver brazing and soldering alloys available.
- Helps you get quick, accurate alloy calculation with calculating tables for all commonly used alloys.

See our catalog in Sweets Product Design file 7/LU.

SEND FOR FREE COPY TODAY!

LUCAS MILHAUPT ENGINEERING COMPANY

5056 South Lake Drive, Cudahy, Wis.

READER / TO EDITOR

Car Comment

To the Editor:

In reading your article "Eight Design Authorities Evaluate 1960's Small Cars," (Nov 2, p 32) and noting the comments made by Mr Robsjohn-Gibbings, the furniture designer, I can't help but feel that he is the one in the proverbial glass house. I've never seen such unfunctional and unpleasant designs as those used in furniture. I will admit that they are original—they look like the product of opium dreams.

—Norman G Watson
Diamond Crystal Salt Co
St Clair, Mich

Metric-dimension Bolts

To the Editor:

I have just finished reading the article on page 89 of the November 9 issue of Product Engineering in which Mr. Robert L. Sproat discusses bolt threads with large-radius roots. Here is a desirable change which will necessitate scrapping taps, dies, and gages in all plants which might use these new bolts, and, obviously, they should have universal application. I therefore make the suggestion that now is the time for American industry to go to metric-dimension bolts, since none of the present stock, in equipment or in parts, would be interchangeable with large-radius root threads.—D R Hull
E I Du Pont De Nemours & Co

• Part of the advantage of large-radius roots is that such bolts can be used in standard tapped holes. The author wrote, "Users of the bolts will not have to make changes—standard taps can still be employed to tap threads into mating parts." However, industry might want to take advantage of this opportunity.—Ed.

The Tale of Melvin

To the Editor:

Once upon a time there was an advertising department of a fairly large steel company where all the office force just loved a big laugh—or even a medium-sized chuckle whenever one was handy —and this was true especially in the morning before the day had started.

The first mail delivery usually included some promotion pieces. If they were unusual like the *Saturday Evening Post* missile that popped out of its box or the lovely purple booklet on "How To Read *Fortune* In Bed," everyone shared in the fun—then everyone became a critic.

One day, without even the glamor or excitement of an intriguing package or deckle-edged cover, but tucked away in that serious technical journal, *Product Engineering*, appeared a lovely story entitled "The Tale of Melvin." Now Melvin worked in this advertising department and when the staff saw his name in print and realized he had become famous, they all "flocked" around to read his story. They always knew Melvin was a thinker—and perhaps an heroic rugged individualist (this developed from fights with his school board) also that he was very fond of shrimp—but no one ever suspected that Melvin was lonely.

To give this story its proper "lived happily ever after," "The Tale of Melvin" was posted on the bulletin board where even the outsiders who don't belong to the advertising department could digest the wisdom of Melvin's attitude. Consequently, everyone in the company has been extra kind to Melvin lately. He may no longer agree that "Thinking is a lonely business" but he's certain that "it keeps you in shrimp!"

—(Mrs.) J. M. Shea, *asst ad mgr*
Crucible Steel Company of America

There is an old-timer, T. M. Rutter,
Whose school-board thinks him an in-
butter
He writes copy for Crucible
Has feelings deducible—
You can't gull "Mel," the chin-jutter.

—Rebutter

COMING EVENTS

JANUARY

11-13 . . . . Institute of Radio Engineers, American Institute of Electrical Engineers, American Society of Quality Control, Electrical Industries Association, 6th National Symposium on Reliability and Quality Control, Statler-Hilton Hotel, Washington, D. C.

11-15 . . . . Society of Automotive Engineers, Annual Meeting, Sheraton-Cadillac and Statler Hotels, Detroit, Mich.

12-15 . . . . Society of Plastics Engineers, 16th Annual Technical Conference, Conrad Hilton Hotel, Chicago.

15 . . . . Malleable Founders Society, Semi-Annual Meeting, Hotel Sheraton-Cleveland, Cleveland, Ohio.

18-21 . . . . American Astronautical Society, 6th Annual Meeting, Statler-Hilton Hotel, New York.

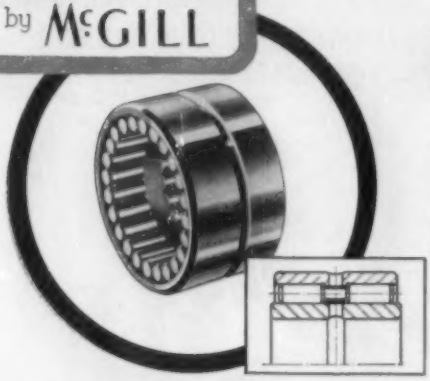
25-28 . . . . Plant Maintenance & Engineering Show, Convention Hall, Philadelphia, Penna.

25-28 . . . . Institute of the Aeronautical Sciences, 28th Annual Meeting, Hotel Astor, New York.

26-27 . . . . Society of Vacuum Coaters, 3rd Annual Meeting, Hotel Biltmore, New York.

31-Feb 5 . . . . American Institute of Electrical Engineers, Winter General Meeting, Hotel Statler, New York.

BEARING TIPS
by McGILL



GUIDEROL®

BEARINGS SOLVE SPECIFIC DESIGN PROBLEMS

with high capacity in small radial space, precision efficiency and "sealed in" lubrication

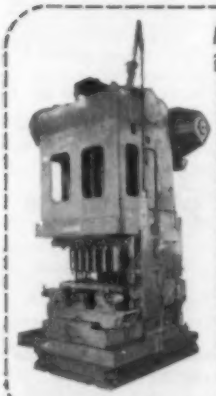
McGILL GUIDEROL Bearings combine the higher inherent capacity of full complement needle roller bearings with "center-guided" roller control. GUIDEROL bearing construction encourages space and cost saving design of shaft and housing components. For a given shaft of 1" a GUIDEROL bearing provides 23% more capacity in ⅜" less housing space than a typical cylindrical roller bearing. A comparable ball bearing uses almost an inch larger OD for 1500# less capacity.

Use the Sealed SGR series to protect GUIDEROL bearing efficiency when contamination exists. Avoid frequent re-lubrications.

GUIDEROL bearings are available with or without separable inner ring. Shaft sizes: ⅝" to 9¼". Capacities to 128,670 lbs. (at 100 RPM).

Bucyrus-Erie Simplifies Assembly and Cuts Lubrication Maintenance 320% with Sealed Guiderol Bearings

BUCYRUS-ERIE CO. has incorporated the advantages of GUIDEROL GR-28RSS, sealed bearings in their 11-B TRANSIT CRANE-EXCAVATOR. The bearings serve as mountings for sheaves in the 11-B boom suspension which is a wire rope system running from a powered cable drum over the sheaves. The GUIDEROL bearings decrease friction and provide a jerk-free lowering and raising of the boom. In addition, they have increased periods between lubrication from once a day to once a month under normal operation. BUCYRUS-ERIE also cites ease of assembly due to holding to close manufacturing tolerances as an additional benefit. Loads on these bearings are approximately 10,000 lbs.; speeds — 56 RPM. Bearings are used in both horizontal and vertical mountings.



Moline Tool Co. Get High Radial Load in Minimum Space

Each of the six spindles of the MOLINE Model 116U hydraulic rail feed, universal joint type drilling machine has two GUIDEROL upper bearings and two GUIDEROL lower bearings. The GUIDEROL bearings replaced bronze sleeve bearings used in previous design of the machine. The GUIDEROL bearings were selected for their ability to get the highest possible radial load in minimum space and still retain the advantages of a precision anti-friction bearing. Vertically mounted, the bearings are lubricated by drip feed oil from the upper drive unit. The unsealed GUIDEROL bearings with open ends permit a free flow and the roller retaining ring acts as an oil ring to pick up and distribute the lubricant.

Guiderol® Bearings Take Heavy Loads of High Volume Hydraulic Pump Service.

GALION ALLSTEEL BODY COMPANY'S combination high volume roller bearing pump and spool valve has been developed to furnish the large volume of high pressure oil needed for fast dumping with Duo-scopic hoists. These pumps operate the hydraulic cylinders on the complete line of Galion trailer dump bodies. Four small GUIDEROL bearings easily accept loads of 3,500 pounds on the driving shaft and 4,500 pounds on the driven shaft. They provide maximum capacity in small radial space with a full complement of race width rollers. These center guided rollers help insure the precision performance required to increase pump capacity to 1,450 PSI at 1,000 RPM.

engineered electrical products

McGILL®

precision needle roller bearings

Send for Free Bearing Catalog No. 52A for complete Data.

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

BLAMING COIL BURN-OUT ON THE SOLENOID? THEN TAKE A CLOSER LOOK AT THE **VALVE!**

SPOOL and POPPET Valves bind and stick as dirt collects... overload solenoid and cause coil burn-out.

"SHEAR SEAL" Valves are not sensitive to dirt... always retain solenoid power margin.

D.C. SOLENOID "SHEAR SEAL" VALVES 0 to 10,000 P. S. I.

A.C. SOLENOID "SHEAR SEAL" VALVES 0 to 10,000 P. S. I.

EXPLOSION PROOF A.C. and D.C.

SOLENOID "SHEAR SEAL" VALVES 0 TO 10,000 P. S. I.

SPOOLS and POPPETS leak... can't compensate for normal wear.

"SHEAR SEAL" Valves stay leakproof... a spring takes up the normal wear.

ASK FOR CATALOG V-59-60

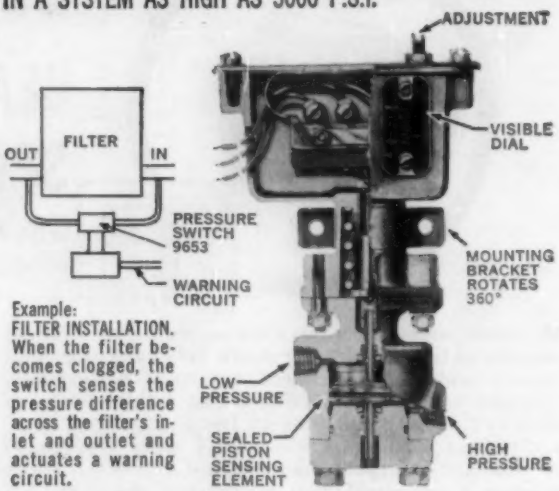
CONTROL VALVE DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

NEW PRESSURE DIFFERENCE SWITCH

SENSES A LOW DIFFERENCE OF 10 P.S.I. EVEN IN A SYSTEM AS HIGH AS 5000 P.S.I.



Example: FILTER INSTALLATION. When the filter becomes clogged, the switch senses the pressure difference across the filter's inlet and outlet and actuates a warning circuit.

The new Model 9653 is constructed to sense a difference from 5 P.S.I. to 140 P.S.I. between two pressures. A sealed piston sensing element actuates an electric circuit on increasing or decreasing of a predetermined pressure difference. It is applicable to oil systems ranging from 50 P.S.I. to 6000 P.S.I. working pressure. A high proof pressure rating of 9000 P.S.I. is your protection against damage from surges and shock loads. Field setting is simplified by means of an external adjustment screw and visible dial.

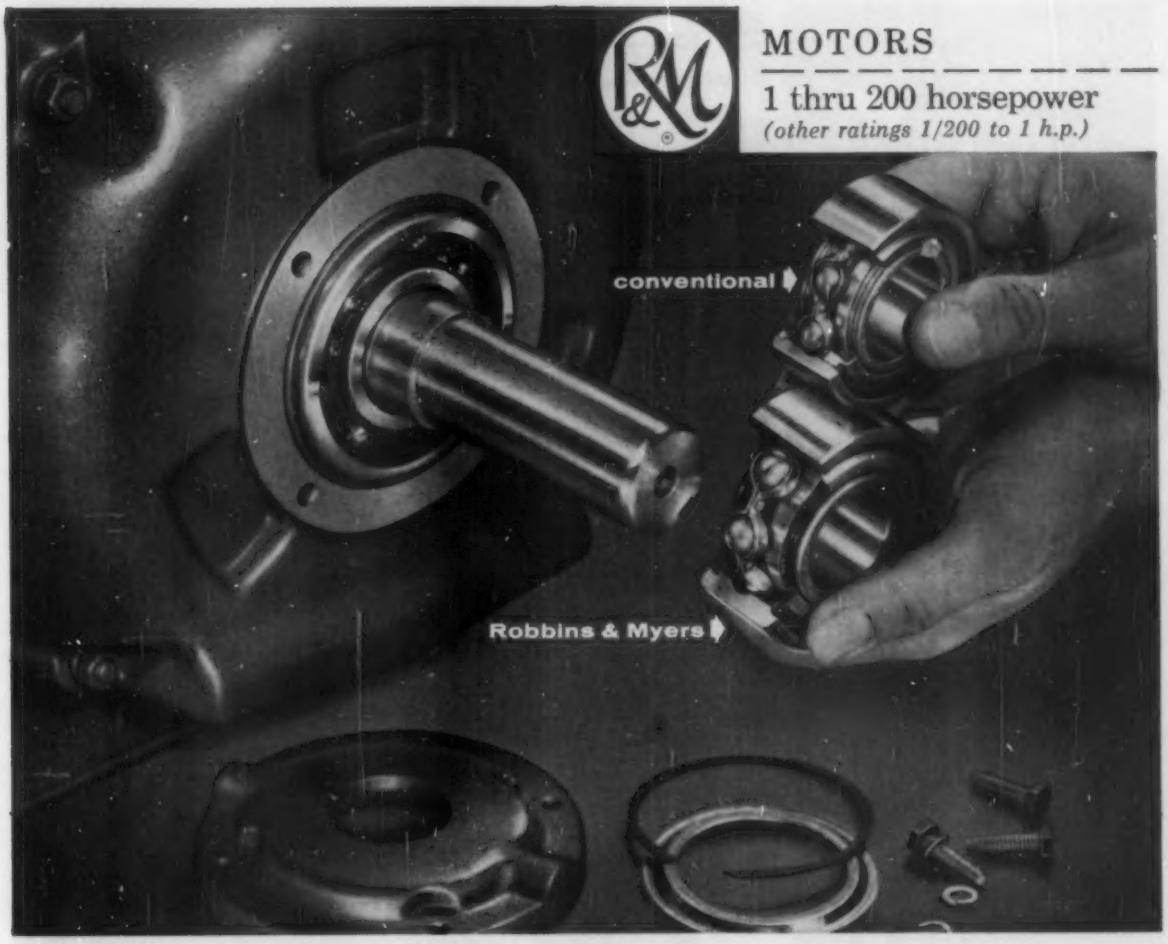
WE BUILD IN	WE DON'T USE
RUGGEDNESS Can take surges— (High proof pressures) Continuous operation— (Millions of cycles) No sticking— (in dirty fluid)	 **LINKAGES & BEARINGS** Which wear quickly —(cause settings to drift and switch to fail).
LABOR & MATERIAL SAVINGS No return drain piping— (Sealed piston) Mounts where convenient (Operates in any position, Not sensitive to vibration)	 **UNSEALED PISTONS** Which add to your installation cost (return piping). Are critical to dirt— (pistons get stuck).

Ask for new pressure switch handbook and catalog '59-'60

PRESSURE SWITCH DIVISION

Barksdale valves

5125 ALCOA AVENUE, LOS ANGELES 58, CALIFORNIA

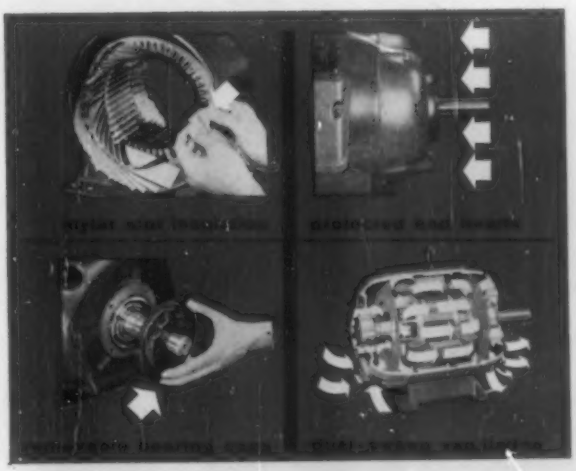


Double Width Bearings Hold More Grease...*Insure Longer Motor Life!*

Bearings in ROBBINS & MYERS motors run in double-width races with extra-large lubricant reservoirs. Bearings are fully sealed and pre-lubricated with laboratory tested grease which resists dust, temperature, humidity and high operating speeds. Tests prove these bearings can withstand six to nine years of severe service without relubrication. Bearings are further protected by metal seals on each side. Seals keep impurities out, prevent failure caused by "forgotten" lubrication or damaging over-lubrication.

R&M insures longer motor life with many additional features: Mylar* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . removable caps for quick bearing inspection and relubrication . . . end heads that give full-height protection . . . dual-sweep ventilation for efficient cooling. For details, write today for Bulletin 520-PRE

**DuPont registered trademark*



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

VELLUMOID

2 VELBUNA FEATURES

VELLUMOID

Unmatched in Gasketing

1. VELBUNA for Dimensional Stability . . . You need close maintenance of dimensions, before and after installation, to provide the best seal. Velbuna's excellent stability over extended periods of time is unmatched by any competitive material.

2. VELBUNA for High Recovery Rate . . . Completely blended with Buna-N synthetic rubber every fibre of Velbuna's homogeneous texture "works" to spring back to its original shape. This results in an extremely high recovery rate over a wide range of compressive loads. Torque loss is negligible.

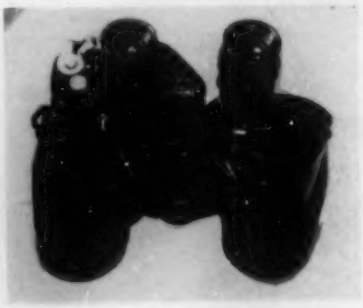
The Velbuna Line of gasketing material is your answer to a broad range of problems where a **firm** but **conformable** material is required. It is especially suited to services involving petroleum oils, greases, fuels, and water. Write for a sample and test it in your own applications!

Write today!
THE VELLUMOID COMPANY
54 Rockdale St.
Worcester, Mass.

VELLUMOID

WRITE TODAY!
THE VELLUMOID COMPANY
WORCESTER, MASS.

FOR YOUR INFORMATION (personal)



Camera thinks big

A binocular that takes pictures is the latest gadget from Japan. The camera has an f:3.7 Panorax lens and a 30-exposure magazine. The binocular itself has 400mm 1.8 teleconversion lenses, magnifies 15 X. The price (US equivalent): about $140. The name: Binoflex. Teikoku Special Optical Laboratory, Kawasaki, developed it.

TV tip—houses aren't antennas

Just connect this little device to your TV set, plug it into your house wiring, and forget about your antenna problems . . .

So say the ads. But the Better Business Bureau is not so optimistic.

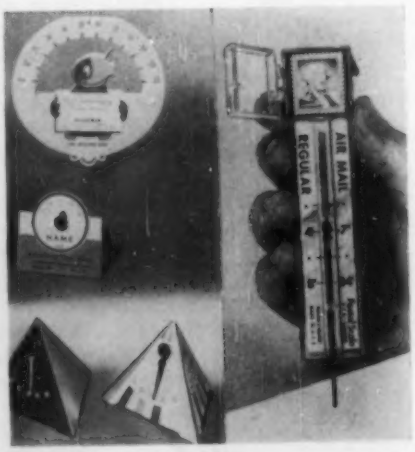
Discussing claims for "miracle socket" antennas that plug into any electrical outlet to "turn your house wiring into a giant TV antenna," NBBB says even the best house wiring is no substitute for a TV antenna. It's designed to have almost the opposite effect—most house wiring (especially in houses built the past 20 years) is grounded and electrically shielded against signal pickup.

Furthermore, TV pickup depends on direction; and for all practical purposes, house wiring has no predictable directional effect. Though exposed line cord, draped directionally, will catch signals of a nearby transmitter, it can't match a well-designed indoor or outdoor antenna; and even this limited directional effect may be negated when the line is led to a wall socket.

Furthermore, says NBBB, there is no correlation between extensive length (that house wiring theoretically could offer as an antenna, for example) and the strength of signal put into the TV set.

Finally, it warns, such devices may be hazardous—full voltage of the house circuit could hit a person or set if condensers in the device are defective or become shorted, and the ac line happens to be plugged into the "hot" lead of the house wiring.

Gadgets and Gimmicks



Little thermometers and a pocket postal scale that carries stamps along with it, are among the latest low-cost items to delight the gadget collector.

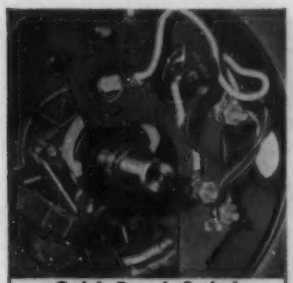
The thermometers are simple little devices consisting of a bimetal coil and a pointer, with or without a plastic button cap, and attached to any one of a dozen paperboard cutouts that can be posted on windows, mounted on auto visors, or hung on the wall.

Though specifically designed for premiums, and not sold in stores, they can be purchased in small quantities direct from the manufacturer, Stegeman Products Inc, 18 E 6th St, Newport, Ky at 20¢ to 25¢ each. Less, of course, for larger amounts. (The usual quantity is about 1000.) —ARG

NO STARTING PROBLEMS

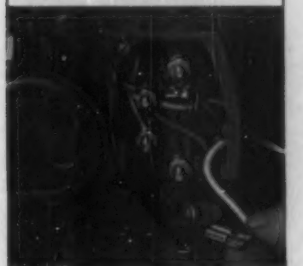
with

WAGNER CAPACITOR-START MOTORS



Quick Break Switch

The starting winding is disconnected from the line by this Wagner designed switch... test proved to make more than a million breaks. (That adds up to two starts per hour for 50 years!)



Quick Connect Terminals

Brass tabs on terminal studs permit quick, easy connection of leads... cut wiring time to speed assembly line production. Simply press the lead receptacle on to the stud—a positive connection is assured.

All-Angle Operation

The sleeve bearing design, in fractional hp ratings, has a positive lubrication system that permits operation in any position... can mean important savings in motor costs to manufacturers.

Pack more power into less space...give long troublefree service...are easy to hook up

Here are general purpose single-phase motors that have high starting torque and high pull-in torque. When used in the proper application and supplied with voltage close to their rating, they'll give positive starts every time. Troublefree operation is assured... thanks to the positive action of the Wagner governor mechanism and long life quick-break switch.

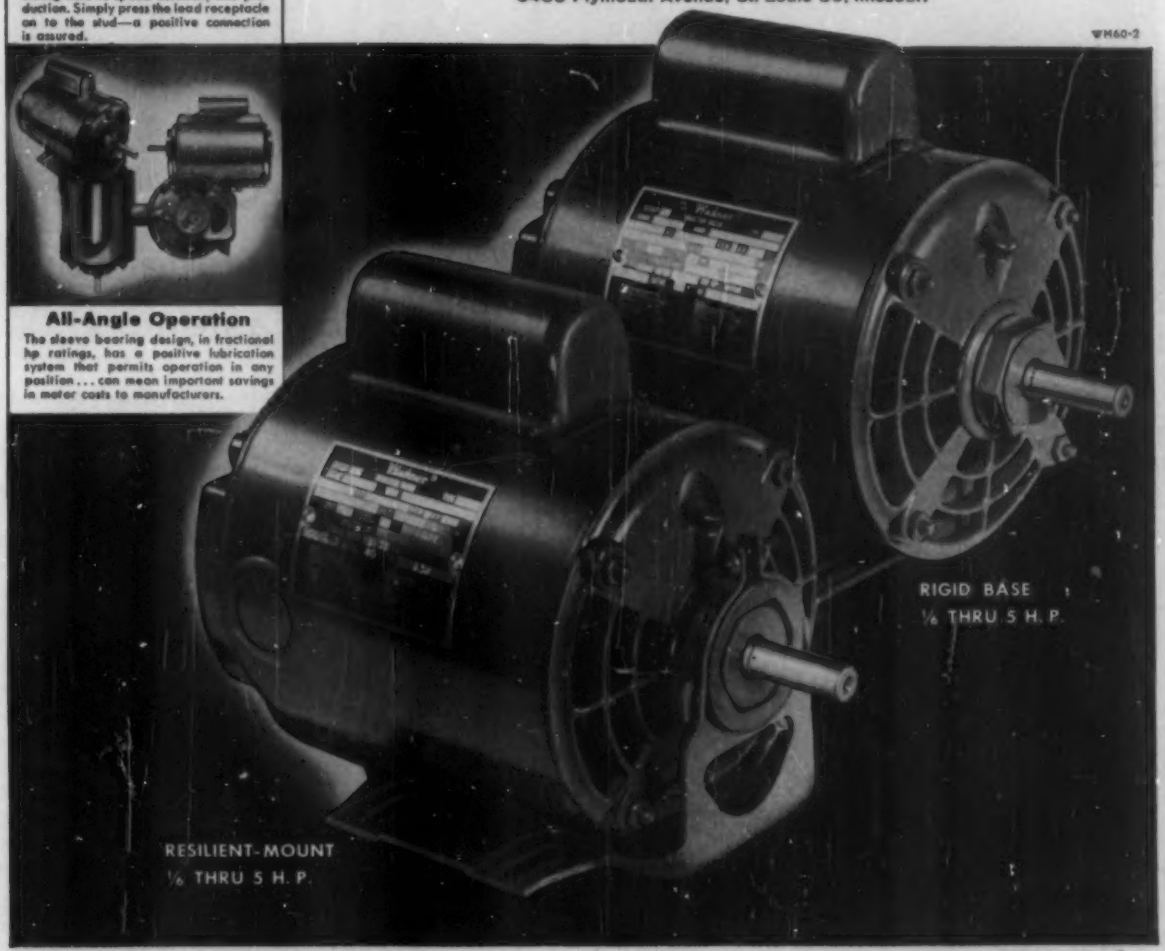
Wagner Type RK Motors pack more power into less space. Small enough to fit in tight spots, their ruggedness is built-in... permits direct mounting. They are available in a range from ⅛ through 5 horsepower, with sleeve or ball bearings, and with rigid bases or resilient mountings. And, sleeve bearing fhp models can be operated in any position.

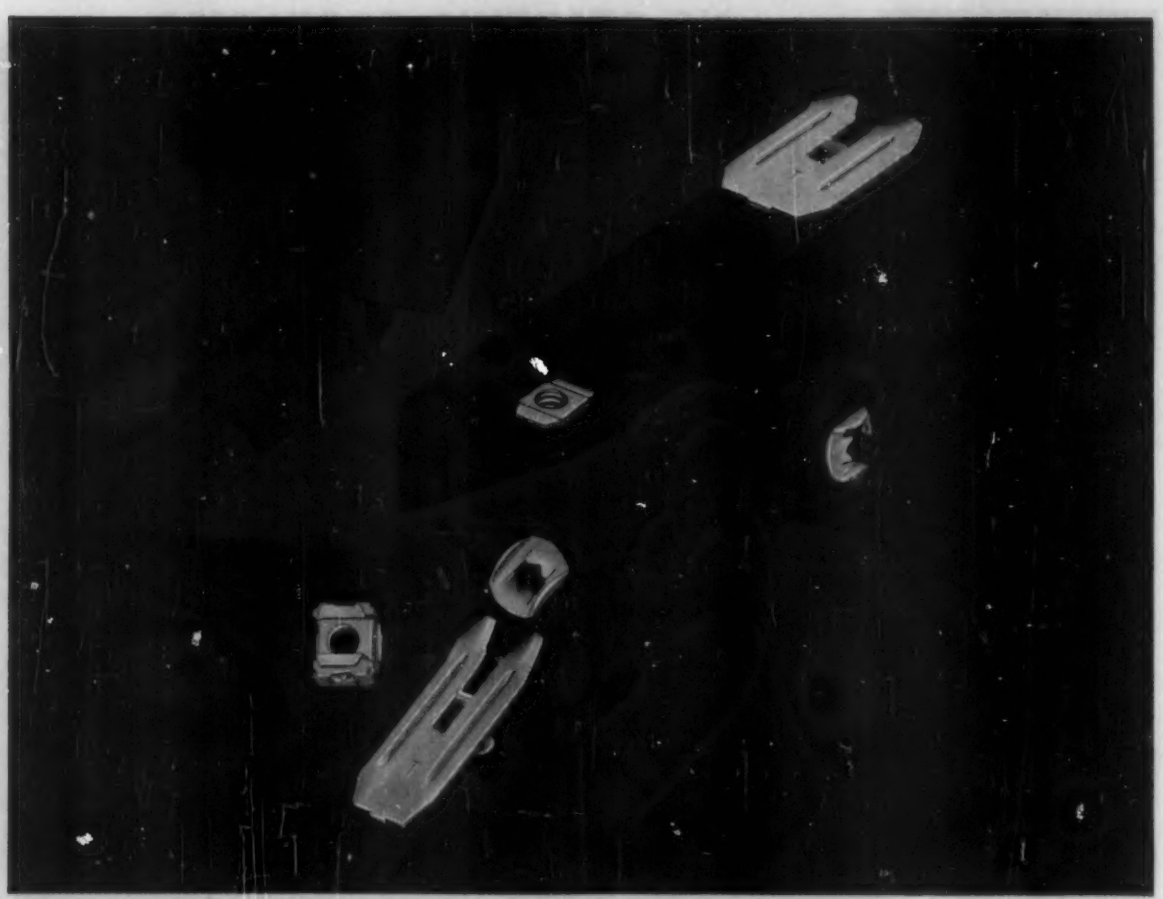
Get these motors from leading distributors in your city, or from Wagner Sales Offices in 32 cities across the country. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-217 gives full details on Capacitor-Start Motors.

Wagner Electric Corporation

6406 Plymouth Avenue, St. Louis 33, Missouri

WM60-2





Assembly costs cut 50% at design stage by Tinnerman **SPEED NUT**® Brand Fasteners!

Fastener ideas worked out between designers at Hillside Metal Products, Inc., and Tinnerman engineers, resulted in the selection of 3 different SPEED NUT types for Hillside's complete line of quality steel office furniture. Hillside estimates "at least a 50% saving in material costs, assembly time and tooling" over ordinary fastening methods. And spring-steel SPEED NUTS hold tight, even through years of hard service.

A special Dart-Type SPEED CLIP® snaps into a punched hole, securely anchors one end of the drawer latching mechanism spring. A standard Push-On SPEED NUT "bites" into a stud; prevents the other spring end plus latching bar from backing off. Desk tops as well as desk and table legs, are attached with the help of SPEED GRIP® Nut Retainers that snap into bolt-receiving position in punched holes. A Push-On completes the file drawer follow block assembly; two more secure each filing cabinet drawer card holder.

This should give you an idea of what a free Fastening Analysis can probably do for you in savings and improvements on present or new products. Look up your Tinnerman representative in the Yellow Pages under "Fasteners". Or write to

TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

PRODUCT ENGINEERING

HORIZONS

January 4, 1960

We approach the

"SCIENTIFIC SIXTIES"

Most of us think of 1929 and 1930, the beginning of our Great Depression, as a long time ago. (Europe had a much longer one called the Dark Ages.) Since then we've had crisis after crisis, jets, television, radar, rockets, satellites, A-bombs, H-bombs, even numerical control, magnetohydrodynamics, solar power, and fuel cells. So it is interesting to go back to Vol I, No. 1, of PRODUCT ENGINEERING to check that long-ago era—and to find a kind of paradox.

In 1930, we published articles on laminated molded materials, aluminum-base die castings, vitreous enamels, malleable castings, hard rubber, electric typewriters, electric ranges, strain gages, electron tubes and mechanical trends in radio, welded joints, friction clutches, damping vibrations, even automation (under another name).

Any of these could be subjects today, still as pertinent as they were then. So were the editorials, on such subjects as too much specialization, professional engineering, designing safety into machines, engineers as executives, rear vs front engines, and new materials and the "new look" in automobiles. These are still important subjects, still basic problems.

When the Product Engineer Emerged

As time goes, thirty years is not very long. But that is just about the life span of design engineering as a distinct and separate function, just about the life span of the professional engineer as such (the National Society of Professional Engineers was not formed until 1934).

Thirty years ago, the design engineer in most plants was submerged in the production department—often a mechanic who could make drawings. Only the larger companies were recognizing him as a separate function and providing him with a staff. This is a far cry from the recognition of engineering even in the smallest companies and the high engineering content of many of our products today.

It is also a very far cry from the subdivision of engineering itself into many functions: research, development, design, stress, test, and the like; and the growth of associated activities such as industrial design, value analysis, product planning, and analytical and testing services.

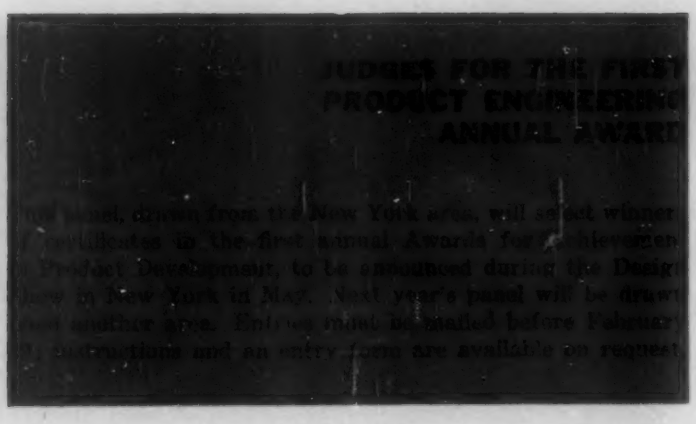
PRODUCT ENGINEERING was initially devoted entirely to the needs of the design engineer of that period—the source of current "hard-core" engineering data. Through the years, your needs have grown, so the coverage of the magazine has grown with them. Such subjects as engineering management and cost control have been covered for years. More recently we have added reports on industrial design, although we wrote the first articles in 1930 after interviews with Walter Dorwin Teague, Henry Dreyfuss, Raymond Loewy, Lurelle Guild, Norman Bel Geddes, Egmont Arens and others.

Two years ago, we recognized the need for prompt news reporting on engineering, science and research by altering our publishing plan from monthly to weekly, alternating between "Design" and "R & D News" issues. At the same time, we expanded "Developments to Watch," added every-other-issue features like the Washington page, "What's Happening in Science," "What's Happening in Materials," "Points of View," and "Trends in Appearance Design." These new features promptly achieved the recognition from you that we had hoped they would. Many more of you are reading PRODUCT ENGINEERING, and your response has also markedly increased.

Improved Service from Product Engineering

Now we are taking another step toward improved service. With this issue, we begin publication of a uniform weekly magazine, containing all the regular features at their previous frequency, or oftener. We are also practically doubling "hard-core" engineering content. To make your reading and reference easier, the news and weekly features from the former R & D News Issue will appear in a special front-of-book section on buff-tinted paper; the engineering material from the former Design Issue will appear following the editorial page, as in the past. The Contents Page has been returned to page 1 for readier reference.

Thus, you may now find the departments and features you prefer in every issue. The magazine has a square backbone for ready filing, the easy-tearout binding has been adopted uniformly, and single reprints of selected articles will continue to be available on request. We are augmenting our full-time staff, already by far the largest in our field, by several engineer-editors to assure you of maximum service, whatever your interests. We will appreciate, as always, your comments and suggestions after you've had time to use this new "package," which we've symbolized by adopting a modern logotype to re-



Renato Contini
Senior Research Scientist
College of Engrg, New York University
First president, Human Factors Society

Arthur M Perrin
President
National Conveyors Co, Inc
Prominent in ASME affairs

place the somewhat dated lettering we'd used for almost a decade.

It is singularly appropriate that we thus modernize and streamline PRODUCT ENGINEERING as we enter the "Scientific Sixties." Academically speaking, this year of 1960 is really the final year of the Fifties (there must always be a tenth year to complete a decade) rather than the first of the Sixties. But it is perhaps well to take a long look ahead at the new decade, because it promises to continue the accelerating pace of change we've had since World War II.

A Look Ten Years Ahead

What will happen in these next ten years? Already the predictions are being published—of houses held up by anti-gravity to catch vagrant breezes, of rocket-propelled postmen, "mail" delivered by satellites (they must mean relayed messages rather than physical letters), of higher-speed, higher-powered automobiles that ride a cushion of air, "thinking machines" and so on.

Actually, none of these things seem very likely to a sophisticated audience. Engineers and scientists know that the five- to seven-year product-development cycle means that products now out of the labs and into the prototype stage will just be gaining public acceptance ten years from now, while ideas currently in the research stage may still be there in 1969.

This does not mean that there will not be new developments, hundreds of them. But most will be in the nature of refinement and gadgetry, each hailed in turn as the greatest development since the wheel. Major trends, as we see them, are in new forms of power, in computers and data handling, in micro-miniaturization, in solid-state physics, in the rise of new metals, stainless, plastics and similar "man-made" materials.

Computers steadily become smaller, cheaper and more versatile, so that it can now be predicted that they can, and will, handle engineering calculations, bank operations, store accounts, industrial accounting to a much greater extent than they already do. We're perilously close to units that can read printing and even handwriting; we're approaching "automatic" postoffices, and all sorts of guidance and control computers are in the works.

Actually, the computer has been a major factor in the development of another field—miniaturiziation. We are now going on to micro-miniaturization, with micromodule elements. Our engineers are "thinking little." The result is a 2 x 3 x 6 in. tape recorder; another battery-operated tape recorder that will put 4 hr of dictation on a ⅛-in.-dia spool; an FM transmitter 0.4 x 1.125 in. that can be swallowed for medical study; a TV camera with a ¼-oz picture tube; pencil-point microphones that can be fed into the heart through a blood vessel; wristband radio; tiny controls for heat, light, air conditioning and kitchen appliances as well as industrial devices; 1-cu-in. radio paging devices with a central control that can page a million people; readily portable controls for doors, lights, and so on. We have a light bulb that will follow a camel through a needle eye, clutches that will go inside a walnut. Meanwhile, the crop of "biggests" in all sort of devices continues to burgeon.

These are tied in with the omnibus classification of solid-state physics, in which moving parts are replaced by electrical conversions. Here is a whole field of controls and other devices just emerging from the laboratory. They show tremendous promise because they at last overcome our greatest problem—wear of moving parts.

The plastics have taken over tremendous areas once

George Habach
Vice-president—Administration
Worthington Corporation
Active in Machine Design Division, ASME

Conrad Jones
Partner
Manager of New-product Planning
Booz, Allen & Hamilton

Robert Redman
Professor, Industrial Design
University of Bridgeport
Most-recent past president, IDI

John H. Robinson, Jr
Manager, Advance Engineering
Portable Appliance Dept
General Electric Company

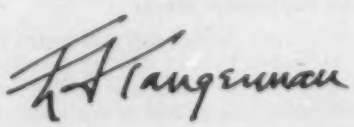
Walter Dorwin Teague, Sr
Walter Dorwin Teague Associates
Outstanding industrial designer
Fellow and past president, ASID

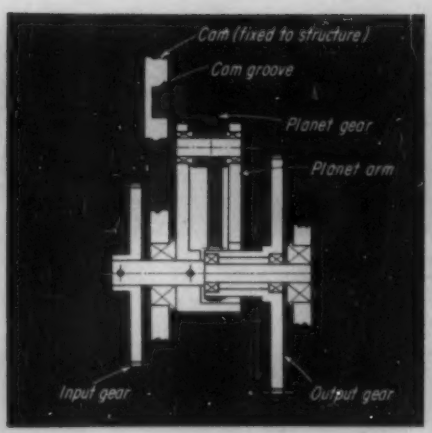
occupied solely by metals. But they are destined to go much further, both as structural materials in an almost endless variety of compositions and properties, and as synthetics derived by petrochemical technology. There are almost no limits to where they can go, their only major limitation being temperature. They overcome the problems of corrosion, temperature change and fatigue, make it possible to combine characteristics—as in self-lubricating materials or flexible piping, offer price reductions that make disposable products (even clothes) almost practical. And there is no danger of shortage of raw material.

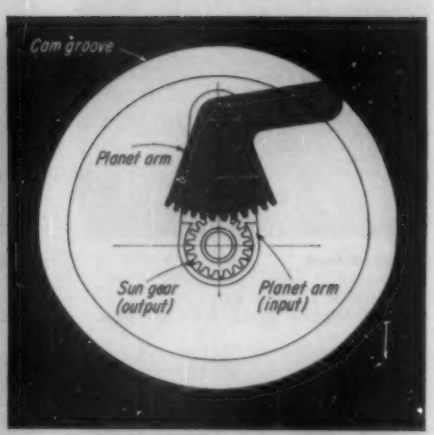
With these bases, it is easy to go hog-wild in predictions for the Scientific Sixties, and too many people already have. The Levacar, running on rails at 200 to 500 miles an hour, supported on a cushion of air, seems a practical though costly communication device, as do rockets for long-distance transmission. But the automobile, guided and cycled by a magnetic band in the roadway, sounds almost as visionary as total smog control. Again, the combined deep-freeze and microwave cooking under pushbutton control projected for kitchens will, we expect, come within the next ten years, but the plastic, vermin-free, fully air-conditioned home rotating with the sun will not. It's mostly a matter of degree.

Awards for Design Engineers

We can all take pride in these developments, but we do feel that individual designers should receive specific recognition. The tendency in our society is to accept the product but not to recognize the designer, particularly because so many designs are today a group, rather than an individual, product. But the men responsible should still be recognized for their contributions. We are, therefore, establishing annual Awards for Achievement in Product Development, which a panel of distinguished judges will select beginning this year. Here will be one way to evaluate the Scientific Sixties—by seeing what developments, in the opinion of informed judges, are important.







1 Construction details of cam-planetary mechanism employed in film drive.

Cam Control Gets More Out of a

PLANETARY GEAR

By incorporating a grooved cam you get a novel mechanism that's able to produce a wide variety of output motions. Author supplies a sample problem showing how to determine the correct gear ratio and cam contour.

JOSEPH KAPLAN, *senior project engineer*
Fairchild Camera & Instrument Corp, Syosset, NY

Do you want more variety in the kinds of output motion given by a planetary gear system? You can have it by controlling the planet with a grooved cam. The method gives the mechanism these additional features:

- Intermittent motion, with long dwells and minimum acceleration and deceleration.
- Cyclic variations in velocity.
- Two levels, or more, of constant speed during each cycle of the input.

The design is not simple because of need to synchronize the output of the planetary system with the cam contour. However, such mechanisms are now at work in film drives and should prove useful in many automatic machines. Here are equations, tables and a step-by-step sequence that will make the procedure easier.

How the Mechanism Works

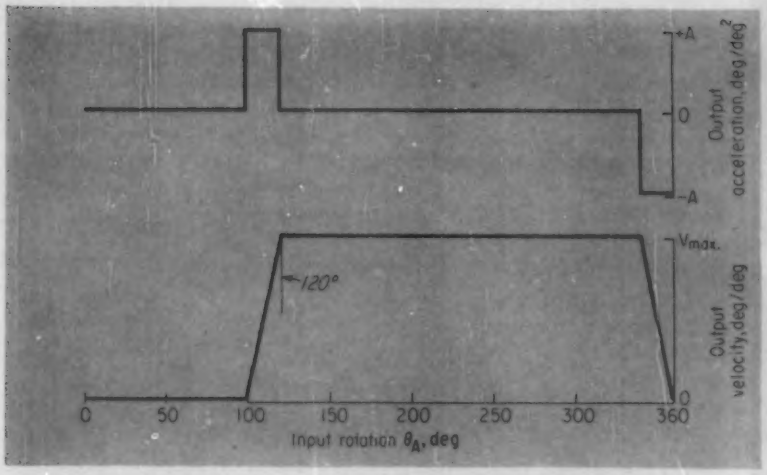
The planet gear need not be cut in full—a gear sector will do because the planet is never permitted to make a full revolution Fig. 1. Sun gear is integral with the output gear. The planet arm is fixed to the input shaft, which is coaxial with the output shaft. Attached to the planet is a follower roller which rides in a cam groove. The cam is fixed to the frame.

The planet arm (input) rotates at constant velocity and makes one revolution with each cycle. Sun gear (output) also makes one revolution during each cycle. Its motion is modified, however, by the oscillatory motion of the planet gear relative to the planet arm. It is this motion that is controlled by the cam (a constant-radius cam would not affect the output, and the drive would give only a constant one-to-one ratio).

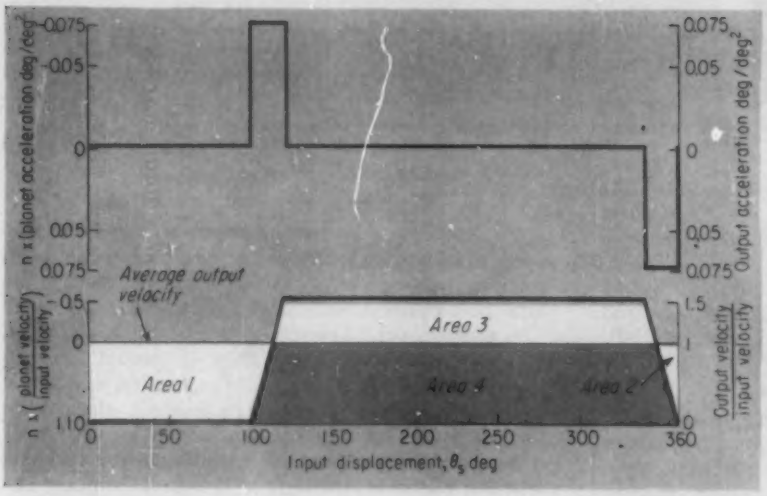
Comparison with Other Devices

A main feature of this cam-planetary mechanism is its ability to produce a wide range of non-homogeneous functions. These functions can be defined by no less than two mathematical expressions, each valid for a discrete portion of the range. This feature is not shared by the more widely known intermittent mechanisms: the external and internal Genevas, the three-gear drive, and the cardioid drive.

Either three-gear or cardiod can provide a dwell pe-



2 Velocity diagram and resulting acceleration during each cycle of input, based on sample problem of an intermittent mechanism.



3 Numerical values for velocity and acceleration. Graphical integration of areas leads to displacement characteristics of output.

riod (See "Dwell Position of 3-Gear Drives," June 8, '59, p 80)—but only for a comparatively short period of the cycle. With the cam-planetary, one can obtain over 180° of dwell during a 360° cycle by employing a 4-to-1 gear ratio between planet and sun.

Shortness of the dwell period is also a limitation of the cam-and-gear mechanism developed by V. S. Beggs and R. S. Beggs (see "Cam and Gears Join to Stop Shock Loads," Sep 16 '57, p 85).

And what about a cam doing the job by itself? This has the disadvantage of producing reciprocating motion. In other words, the output will always reverse during the cycle —a condition unacceptable in many applications.

Design Procedure

Basic equation for an epicyclic gear train is:

$$d\theta_S = d\theta_A - n\, d\theta_{P\text{-}A}$$

where: $d\theta_S$ = rotation of sun gear (output), deg
$d\theta_A$ = rotation of planet arm (input), deg
$d\theta_{P\text{-}A}$ = rotation of planet gear with respect to arm, deg
n = ratio of planet to sun gear.

The required output of the system is usually specified in the form of kinematic curves. Design procedure then is to:

- Select the proper planet-sun gear ratio
- Develop the equations of the planet motion (which also functions as a cam follower)
- Compute the proper cam contour

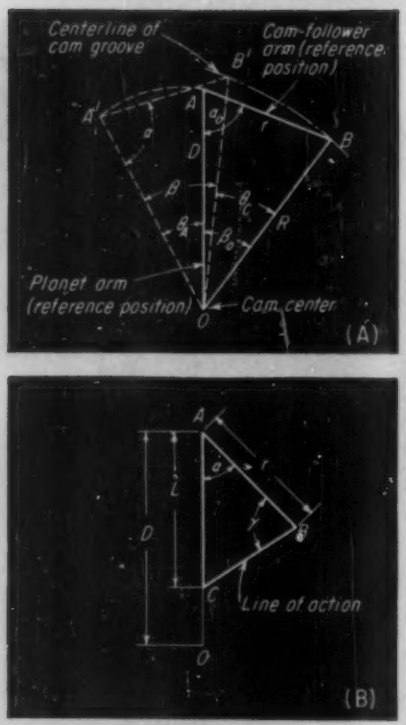
PROBLEM—Design a Constant-velocity mechanism with 100° dwell

Desired output, Fig 2, goes through four stages:

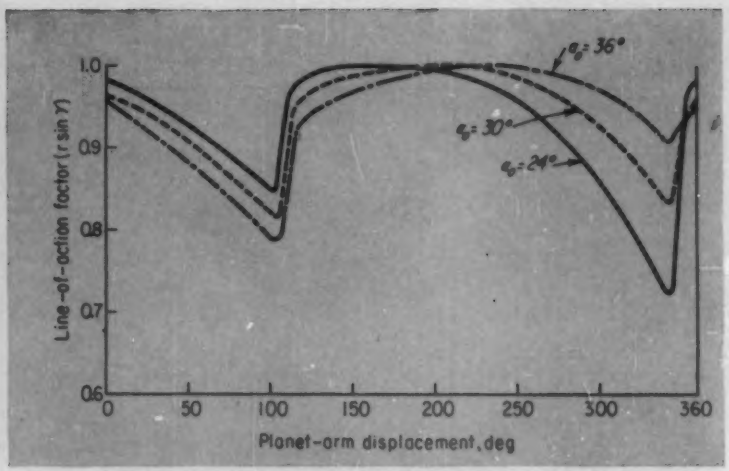
1. Dwell period: 0° to 100°
2. Acceleration phase: 100° to 120°
3. Constant-velocity phase: 120° to 340°
4. Deceleration phase: 340° to 360°

Selection of Planet-sun gear ratio

Table I, p 41, lists both known and computed values for acceleration, velocity and displacement of the output. Known conditions are the initial conditions of velocity



4 Geometry of cam follower (A) and line of action (B).



5 Influence of starting angles, α_0, on line-of-action characteristics.

and displacement; thus, for $\theta_A = 0°$, $d\theta_s = 0$, $\theta_s = 0$.

Acceleration between 100 and 120° (Stage 2) is not known; so is assigned an arbitrary value of A. Velocity and displacement for this stage are obtained by a single and double integration of acceleration. Thus, at $\theta_A = 120°$:

$$d\theta_s = A(120-100) = 20A$$
$$\text{and } \theta_s = (A/2)\,(120-100)^2 = 200A.$$

Acceleration for Stage 3 is zero. Consequently, $d\theta_s = 20A$ (initial condition). Integration of velocity equation yields $20A\ (\theta_A - 120°)$, and adding the initial-displacement condition of 200A yields the displacement equation. Same procedure is followed for determining velocity and displacement for Stage 4.

Acceleration A can now be calculated with the aid of the displacement at the end of cycle (360°):

$$4800\,A = 360°$$
$$A = 360/4800 = 0.075 \text{ deg/deg}^2$$

and the maximum velocity becomes:

$$d\theta_s \text{ (max)} = 20A = (20)\,(0.075) = 1.5 \text{ deg/deg}$$

Velocity curve can now be plotted with max-velocity ratio as 1.5, Fig 3. Average-velocity ratio is equal to one. This must always hold true if output rotates 360° for a 360° rotation of input.

Areas 1, 2 and 3 represent the motion imparted to the sun gear by the oscillations of the planet gear. Areas 1 and 2, located below the average output velocity level, represent subtractive motion from the epicyclic arm, while Area 3, located above, represents addition motion. Area 3 = Area 1 + Area 2 = displacement of θ_s caused by ½ oscillation of the planet.

Therefore, displacement represented by Area 3 is:

$$\theta = \frac{\text{Area 3}}{\text{Area 1} + \text{Area 2} + \text{Area 4}}\,(360).$$

To determine a suitable planet-to-sun ratio, it is sufficient to approximate integrated values of the area by counting squares. Integration of areas, and substitution into above equation yields $\theta_s = 113°$.

A cam-follower displacement must now be assumed. Displacements much smaller than 45° would result in high gear ratios. These are usually undesirable; so are cam-follower displacements much larger than 45° which, while yielding smaller gear ratios, introduce poor cam action. Assuming a displacement of 45°, which is also the rotation of sector relative to arm, the gear ratio between planet and sun is:

$$n = 113/45 \approx 2.5$$

Motion of Planet

Velocity and acceleration curves, based on the 2.5 gear ratio, are also plotted in Fig 3. Max planet ratio is 1.5/2.5 = 0.4; minimum is −0.2. Acceleration and deceleration values are ±0.075/2.5 = ±0.03.

Kinematic equations of the motion of the planet are shown in Table II (derived as in Table I). Limits of the planet excursion can be found by equating each of the velocity equations, between 100°-120°, and between 340°-360°, to zero. Thus:

$$0.4 - 0.03\,(\theta_A - 100) = 0$$

or

$$\theta_A = \frac{0.4 + 3}{0.03} = 113\,\frac{1°}{3}$$

This value is substituted into the displacement equation for $\theta_{P\text{-}A}$ during the 100°-120° phase (Table II), and the planet excursion is found to be 42⅔°. Similarly the other excursion limit is minus 2⅔° at the 346⅔° of the input. The full excursion of the planet is 42⅔° + 2⅔° = 45⅓°.

Design of the Cam

Information for the fabrication of a cam is usually specified in terms of the angular rotation, θ_c, of the cam blank and the radial distance, R, between the center of the follower roller and the cam axis of rotation Fig 4 (A). This relationship can be expressed by the equations:

$$\theta_c = \theta_A + \beta_o - \beta \quad (1)$$

and

$$R = D^2 + r^2 - 2Dr\cos\alpha \quad (2)$$

where

$$\alpha = \alpha_o + \theta_{P\text{-}A} \quad (3)$$

and

$$\sin\beta = \frac{r}{R}\sin\alpha \quad (4)$$

Here, α_o and β_o are starting-position angles for the case when the cam displacement is zero. Distance r is the cam-follower length. Magnitude of α_o can be determined by plotting a family of curves representing the line of action of the follower as a function of displacement angle of the planet arm. The variable is reference angle α_o, shown plotted for 24°, 30° and 35°, Fig 5.

Geometric relationship is defined in Fig 4 (B). Line OA represents the planet arm of length D. Line-of-action of force between cam and follower passes through the center of follower roller B and through C. This line is coincident with the line joining the center of the follower roller and center of curvature of the contact point between cam and follower roller. Length L is a function of the velocity ratio of the follower to the cam and is defined as follows:

$$\frac{OC}{AC} = \frac{D-L}{L} = \frac{d\theta_{P\text{-}A}}{d\theta_A} \quad (5)$$

Length r should approximately equal the min value for L which occurs when $d\theta_{P\text{-}A}/d\theta_A$ is maximum. Thus, for 0.4 (see Table II), $r = 0.714D$. The force along the line of action has a moment arm about A equal to $r(\sin\gamma)$. Value for sin γ can be obtained from

$$\sin\gamma = \frac{L\sin\alpha}{\sqrt{L^2 + r^2 - 2Lr\cos\alpha}} \quad (6)$$

Values for $\theta_{P\text{-}A}$ and $d\theta_{P\text{-}A}/d\theta_A$ in Table III are calculated with the aid of values in Table II. Values for L, α and sin γ are obtained from Eq (3), (5) and (6). For a center distance, $D = 1.4$ and a planet-to-sun ratio, $n = 2.5$, distance $r = 1.0$.

For the three curves plotted in Fig 5, $\alpha_o = 30°$ shows the best line-of-action characteristics because the min line-of-action factors are higher than the minimum for 24° and 36°. Once α_o is chosen, one can proceed with the aid of Eq (1) and (2) to calculate the cam-fabrication data.

For REPRINT of above article, just check P26 on one of the Reader Service cards bound in this issue.

TABLE I—Output Values of Sun Gear

Input	Acceleration	Velocity	Displacement
θ_A, (deg)	$d^2\theta_S$, (deg/deg^2)	$d\theta_S$, (deg/deg)	θ_S, deg
0		0	0 (starting point)
	0	0	0
100		0	0
	A (assumed)	$A(\theta_A - 100)$	$\frac{A}{2}(\theta_A - 100)^2$
120		$A(120-100) = 20A$	$A(120-100)^2/2 = 200A$
	0	$20A$	$200A + 20A(\theta_A - 120)$
340		20A	$4600A$
	$-A$	$20A - A(\theta_A - 340)$	$4600A + 20A(\theta_A - 340) - \frac{A}{2}(\theta_A - 340)^2$
360		0	$4800A$

TABLE II—Motion of Planet

Input	Accel.	Velocity	Displacement
θ_A (deg)	$\frac{d^2\theta_{P\text{-}A}}{d\theta^2_A}$	$\frac{d\theta_{P\text{-}A}}{d\theta_A}$	$\theta_{P\text{-}A}$
0		0.4	0
	0	0.4	$0.4\theta_A$
100		0.4	40
	−0.03	$0.4 - 0.03(\theta_A - 100)$	$40 + 0.4(\theta_A - 100) - 0.015(\theta_A - 100)^2$
120		−0.2	42
	0	−0.2	$42 - .2(\theta_A - 120)$
340		−0.2	−2
	0.03	$-0.2 + 0.03(\theta_A - 340)$	$-2 - 0.2(\theta_A - 340) + 0.015(\theta_A - 340)^2$
360		0.4	0

TABLE III—Line-of-action Factors for $\alpha_o = 30°$

θ_A	$\theta_{P\text{-}A}$	$d\theta_{P\text{-}A}$	α	L	$r\sin\gamma$
0	0	0.4	30	1.00	0.965
40	16	0.4	46	1.00	0.920
80	32	0.4	62	1.00	0.857
120	42	−0.2	72	1.75	0.964
160	34	−0.2	64	1.75	0.989
200	26	−0.2	56	1.75	1.000
240	18	−0.2	48	1.75	0.991
280	10	−0.2	40	1.75	0.958
320	2	−0.2	32	1.75	0.887
360	0	0.4	30	1.00	0.965

EDITOR'S NOTE—In the above article, the author refers to the external and internal Genevas, and the cardioid drive. For design details see Sigmund Rappaport's articles in PRODUCT ENGINEERING:

The External Geneva Wheel, July '49, p 110

The Internal Geneva Wheel, Aug '49, p 109

The Cardioid Drive, April '50, p 132

For details on two other recent innovations in the planetary-gear field, see:

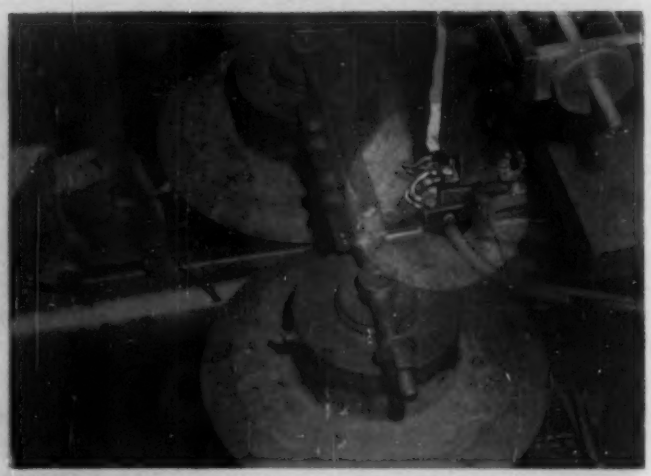
The Planetary Friction Drive, Oct 12, '59, p 79—Gears are replaced with preloaded friction rollers, resulting in smooth, quiet operation (Free reprint, P12).

Novel Concept Gives Record Gear Ratios, June 22 '59, p 67—Fantastically high speed ratios are obtained by pairing helical with spur gears (Reprint E 88).

HIGH FREQUENCY— what it means to WELDING DESIGN

Operate an electric welder at the higher frequencies—say, 450 kc—and you can get stronger welds in a wider variety of materials. But this high-frequency current works differently than the 60 cycles in conventional welding. Here's what h-f welding can do for you.

RICHARD J ALLEN, *research engineer*
New Rochelle Tool Corp



Concentrated power gives high-speed welding in this compact tube mill. Rolled sheet entering from right is heated by h-f current supplied at water-cooled welding head, then passes between pressure rolls that forge the weld. Cutter, at left, removes flash.

Current alternating at 450 kilocycles is the source of energy now handling man-sized jobs in industrial heating. Revived for its unique features, which bring different concepts to the field of welding, versatility of the h-f current explains why it's taking work away from entrenched power sources.

How It Works

High frequency (300 to 500-kc) current heats metal by resistance. It is not to be confused with the 10 to 50-kc power used in induction heating. The higher frequency resistance power has several distinct features. It offers:

No contact losses. Surface or oxide films are not barriers to transfer of electricity. At these frequencies, insulating films become conductors, so current can be carried into the metal with very small contacts and light pressure. Higher voltages are used; also effective resistance of the heated materials at these frequencies is higher, further reducing the current required. With hot-rolled steel, for example, sliding contacts ¼ by ⅜ in. can carry as much as 1000 amps through the scale without arcing or sparking.

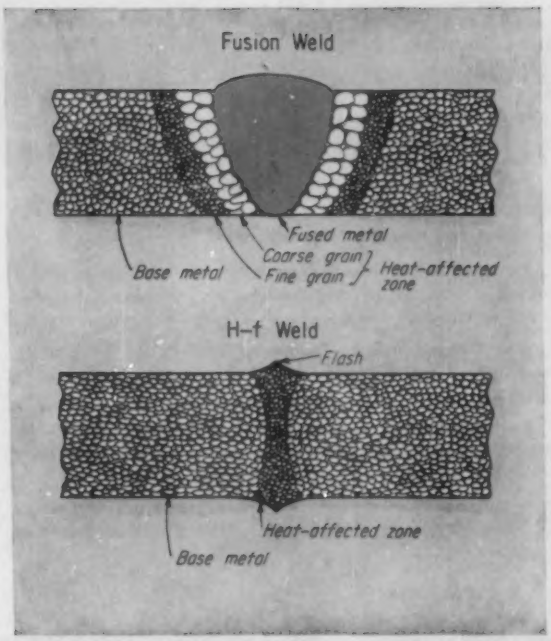
Easily controlled path. High-frequency power follows the path of low inductance rather than low resistance. By placing one of the return conductors close to a steel workpiece, current can be detoured to follow the conductor as much as 50 in. before it returns to a second contact only 2 in. away from the first one. Thus it can harden odd-shaped parts. In welding, the closer the current is to its return path, the more the current will crowd to the surface near the return path, giving high current densities. This places the heat at the exact spot where it is needed. Often it can be limited to a depth of only 0.010 in.

How to Use H-f

Ordinary resistance welding is sensitive to surface conditions. Current travels directly between two electrodes through the metal parts. It crosses three gaps, two between electrodes and work, and one across the weld materials. Effective heating of the weld zone depends upon keeping the resistance at the weld surface higher than that at the electrode contact surfaces. At the same time, the weld surfaces must be kept clean so that oxides will not be included in the weld nugget.

By contrast, high-frequency welding can best be visualized as V-shaped current flow. A contact brings current into the work at one leg of the V; it travels down the leg, crosses at the apex where the metal is joined, and returns up the other leg. Current flow is not dependent upon surface conditions at the contact or at the weld joint. The metal is pushed from the contacts to the apex of the V. The parts are forced together by rolls which supply pressure sufficient to squeeze out any molten metal. This bonds the metal in its plastic range, making a forged weld with no fusion zone.

High-frequency welding is most adaptable for continuous-seam welds. Spot welds are not feasible.



H-f method is best of the forged-weld techniques, which are distinguished by narrowness of heat-affected zone. Fusion welding gives much broader zone.

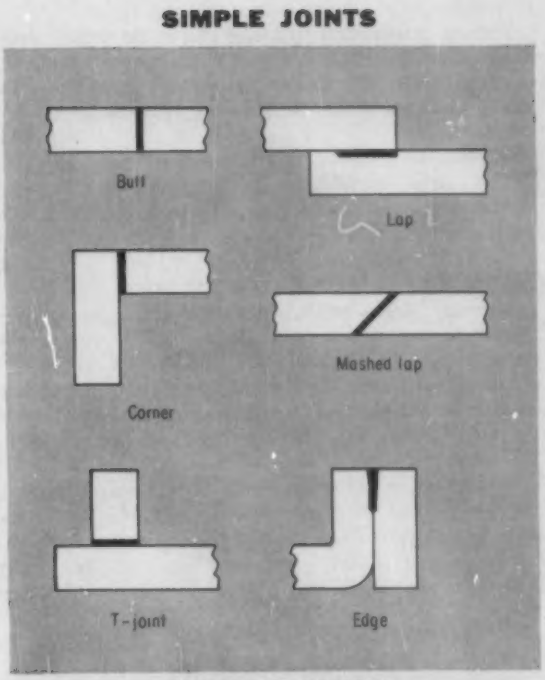
What It Means to Design

Because heating is no longer dependent on surface (or on arc characteristics) good welds are almost certain for any metal. Metals that form thick protective oxides can be welded without special cleaning cycles or flux-coated rods. There is no arc, therefore arc stability is not a problem as in flash-butt welding. This cuts weld-development time, especially for the new materials such as zirconium or zircalloy. (These reactive metals require argon shields.)

Elimination of the fusion zone, and a smaller heat-affected zone, combine to give stronger welds. In some metals this can be controlled so that cold-worked metals retain all or most of their properties. This means high joint efficiencies. For some metals it may be the difference between whether they can be welded or not. For example, 100%-conductivity copper, which has high thermal conductivity, is very susceptible to hot tears while molten. However, welds can be made consistently in this material if the fused zone is eliminated.

All the metals attempted to date have been welded. They include: aluminum and its alloys, mild steel, high-carbon and tool steels, stainless, copper, brass, bronze, Monel, Inconel, Incaloy and zirconium and its alloys.

Copper sheathing can now be welded around a steel core—impossible by other methods. Formerly copper was cast or plated around a steel core and then swaged or drawn down to size. Tube and pipe of 100%-conductivity copper can be more economically produced by welding than by piercing and drawing. With some aluminum



Wide choice of joints is offered by h-f forged welding. Two groups of sketches, above, show typical seam configurations for joining sheet and tube.

alloys, this process is competitive in price with extruding for tubular shapes. It also can produce a work-hardened tube at no additional cost. The heat from extruding aluminum removes hardened properties, so strength must be restored by redrawing or heat treating again.

Various nonstandard structural shapes are readily made. For standard materials, like steel, this allows design to put the metal where it is needed. In the newer materials, this means structural shapes can be made from available sheet stock.

Absence of a fusion zone also allows the joining of certain metal combinations. For example, mild steel can be welded to tool steel, stainless to carbon steel, mild steel to copper.

Various Shapes Possible

Although welds must be continuous, shapes are not limited to straight-line parts. Welds can go around the circumference, join tapered parts, or butt-weld curved ends of corrugated sheet. Main requirement is that the welded stock have a fairly uniform thickness from beginning of the weld to the end. This tends to limit the process to the welding of sheet or plate.

Welding thin materials is the outstanding advantage for this method because contacts need only light pressures. Butt welds can be made in sheet as thin as 0.004 in. but alignment of the edges is difficult, so thin sheet should be joined with a lap or mashed lap weld where possible. In heavy materials, such as $\frac{3}{8}$-in. steel speeds are over 50 ft per min. The upper limit for the 280-kw units is about $\frac{3}{8}$ in. in steel. Higher power units are currently being developed.

Adaptable for Other Metals

The same welding head can be used with equal ease on a large variety of metals. Changeover does require adjustment in power input and in the speed of welding but otherwise the equipment is the same. Speed of welding is independent of shape of the part or of size other than thickness of stock at the weld joint.

EDITOR'S NOTE: For more on welding and other joining processes, and how they influence design:

How to Get Stronger Parts from Work-hardened Sheetmetal, Oct 26 '59, p 76. Design for high-efficiency spotwelded joints in hardened sheetmetal.

One Temperature for Successive Brazes, Dec 8 '58, p 84. How tighter control allows multiple brazing without reducing operating temperature of the final assembly.

Engineering Roundup of Assembly Methods, June 8 '59, p 91. A PRODUCT ENGINEERING special report on how to solve tough assembly problems.

For joining with adhesives see: **How to Calculate Stresses in Adhesive Joints,** July 7 '58, p 64, and **Which Adhesive for What,** Mar 17 '58, p 79.

HOW TO PROTECT PANEL INSTRUMENTS FROM SHOCK AND EXPLOSION HAZARDS

FRED J LINGEL
Instrument Department
General Electric Co
Lynn, Mass

Panel-mounted electrical indicating instruments, because they are "aimed" at the eyes of the operator, may at times produce a personnel hazard through high-voltage shock, or explosion arising from failure of some other component in the system.

High-voltage shock may come from breakdown of insulation somewhere that places a high potential on the case, glass bezel or zero adjuster. To protect against this hazard use a recessed panel, separate cover glass, plastic front, plastic case or grounded metal case. Full plastic case and separate plastic front will also give added resistance to mechanical shock, and give added protection against impact from a metal part that might drop on the cover and touch the instrument mechanism.

Explosion hazards can also arise through an insulation breakdown that produces a high current surge on a regular low voltage instrument. For example, breakdown of a blocking capacitor in the plate circuit of a transmitter can induce high current in a grid milliameter. Such a surge can vaporize the instrument shunt, generating gas rapidly enough to blow out the cover glass into the face of the operator.

Protection requires checking all instrument circuits for possibility of abnormal high current at high voltage, particularly for dc milliameters, low-range ammeters and some types of low-range self-contained rectifier instruments. Specify, instead, a low-range millivoltmeter with an external shunt that is out in the open. Or mount an external fuse in series with the instrument. This will not protect the instrument from damage but will reduce the possibility of an explosion inside the case. A heavier glass or plastic front can be used with a blow-off vent in the back of the instrument, but may cost more than an external fuse.

The same potential hazards are faced in controlling and recording instruments that are intended for frequent close-range observation.

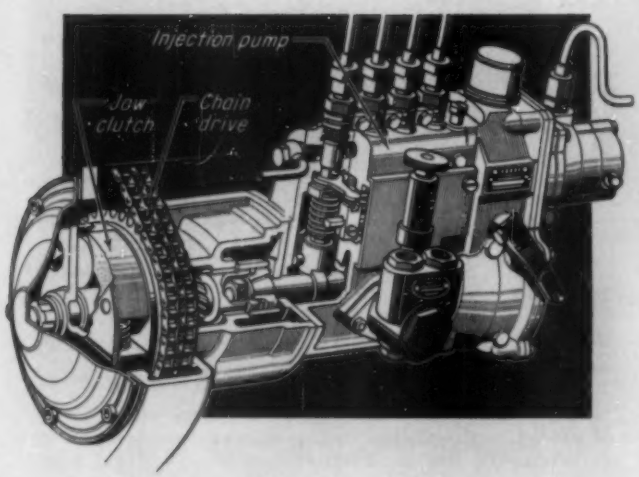
EDITOR'S NOTE: Two recent articles discuss problems in designing for safety:

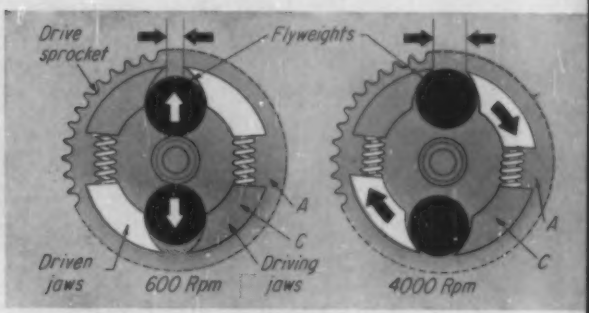
Safety First — with Research Equipment, Jan 19 '59, p 82, outlines the steps that will put safeguards where needed in the design of test equipment.

When You Have to Flameproof a Product, Aug 3 '59, p 38, discusses the various types of flammability tests and treatments, and lists sources of information on materials, components and flame-test equipment.

Spinning Weights Improve Fuel Control

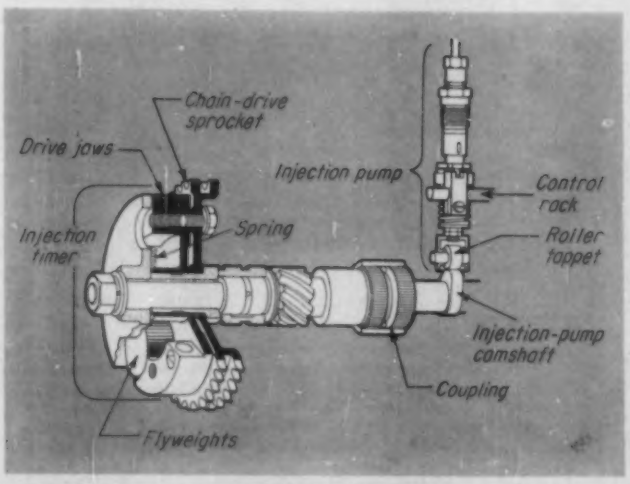
They serve as a centrifugal timer that controls fuel-injection pulse over wide speed range in this diesel-powered auto. Jaw clutch advances timing to keep pace with engine speed.





Jaw clutch . . . mounted on the fuel-injector drive has jaws separated by a pair of centrifugal weights. These move outward as engine speed increases, forcing the jaws apart against the clutch springs. Result is the driven member of the timer is advanced in relation to driving member (A).

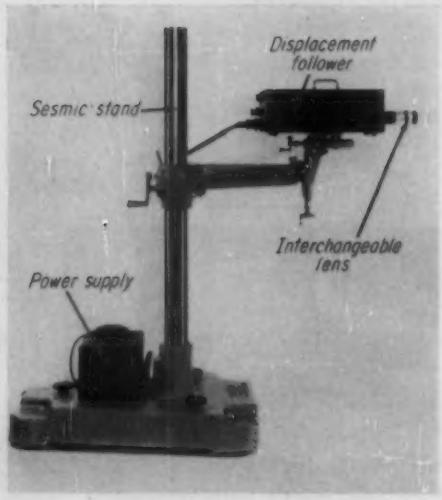
The drive jaws are bolted to a chain-drive sprocket that operates the timer. The driven jaws (C) are bolted to the end of a camshaft that operates individual injection pumps. Torque is transmitted through the jaws by the flyweights inserted between them. Since the jaws are bolted to their backing plates they cannot move outward but have to rotate with respect to each other. This produces the required fuel-injection advance as engine speed increases.

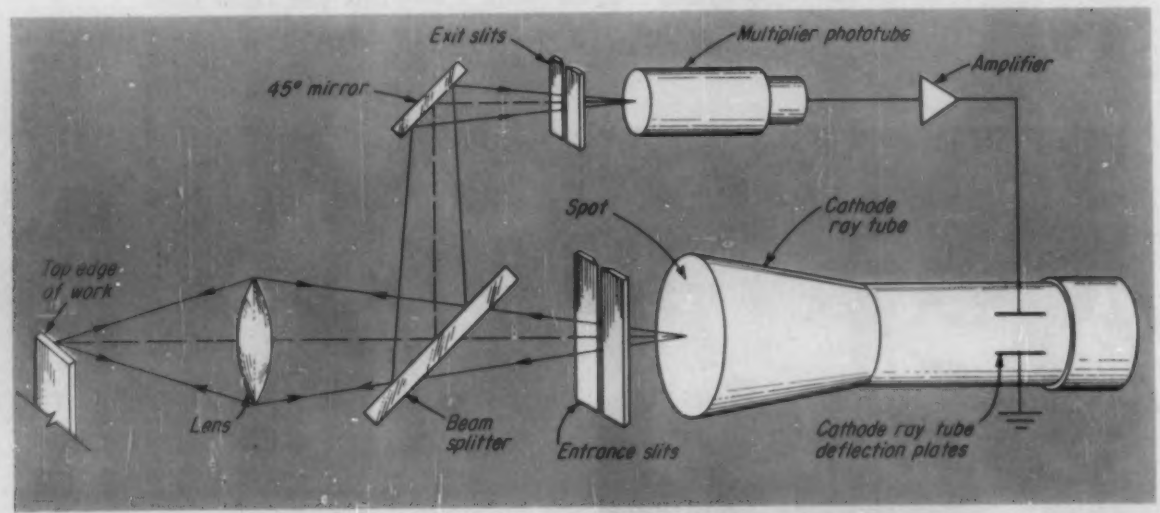


PS . . . The Daimler-Benz idea here is to prevent knock and roughness in high-speed diesels, where ignition must occur before too much fuel has been injected. The centrifugal governor controls time of injection as well as rate and quantity of fuel injected. Jaw clutch on these diesels produces smooth operation over a range extending from 600 to 4000 rpm. The 190D Sedan is produced by Daimler-Benz AG Unter-Tuerkheim, Stuttgart, West Germany.

Spot of Light Follows Workpiece

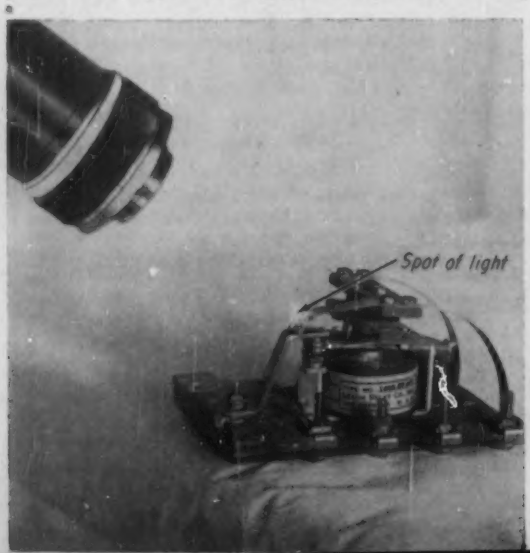
Non-contacting displacement follower uses a cathode-ray beam to track motion. It follows part movements accurately and can be used on any material regardless of shape or composition.





Spot of light . . . generated by cathode-ray tube is focused on top edge of the work. Reflected light is returned through the lens and reflected by beam splitter and 45° mirror to multiplier phototube. Narrow exit slits (0.010 in.) shield the phototube from stray light.

On the work, half the spot is above the edge and half below. Light from the bottom half is reflected to the photocell. The photocell servo system is designed to maintain this 50-50 split of the light spot. When the edge moves up, more light is reflected to the photocell and its electronic servo corrects by deflecting the spot up. When the edge drops, less light is reflected to the photocell and servo correction lowers the spot to restore the light balance. In this way the projected spot follows work motion exactly. Output is taken directly from the cathode-ray tube deflection plates and actual displacement may be shown on an oscilloscope, read from a meter, or recorded.

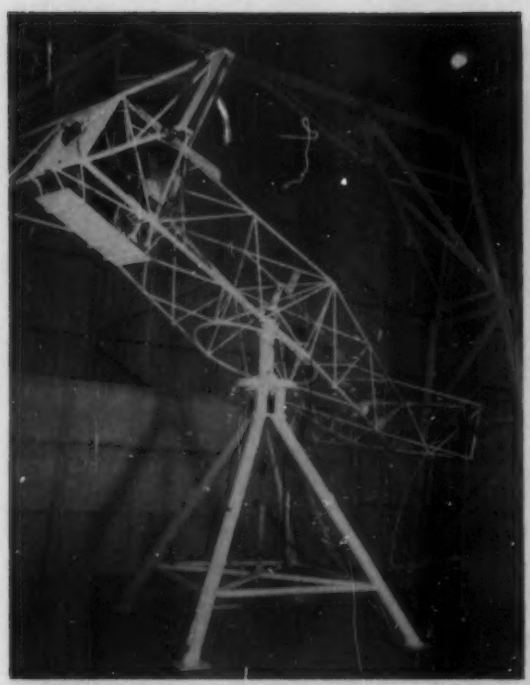


Relay contact motion . . . is checked by follower. Projected spot of light (0.001 in. dia) locks on top edge of contact. Output of instrument shows all motion and time characteristics of relay during cycling, such as bounce, rise-time and duration of latch up. Displacement may be measured in any plane or additional followers used to record motion in several axes at one time. Spot may also be locked onto edge of spring or wire where thickness is as low as 0.00002 in.

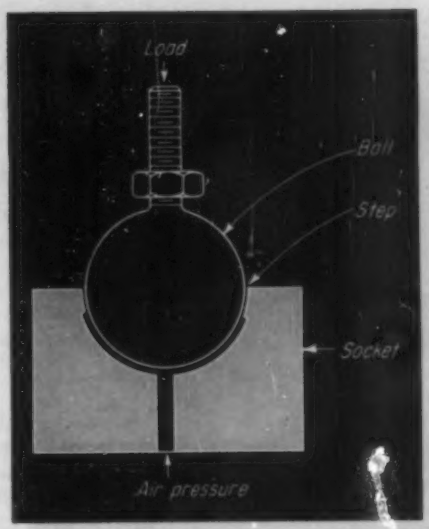
PS . . . Full-scale range of the follower is variable from 0.050 to 2 in. depending on lens used. Resolution as fine as 0.000,050 in. or 0.1% of full scale) is possible when operating in daylight conditions. Complete system consists of Model 701 Displacement Follower, power supply, tripod or stand, and five interchangeable lenses. Produced by Optron Corp, Santa Barbara, California.

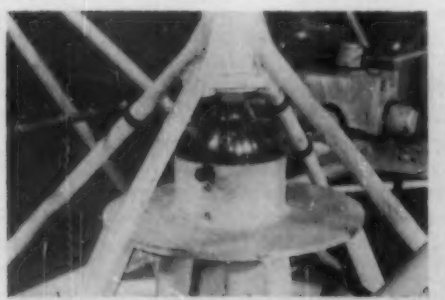
Space Simulator Floats on Air

A minimum-friction air bearing is key to successful operation of this simulator—free to rotate around a point in roll, pitch and yaw. The simulator checks out the attitude-control systems of space vehicles.

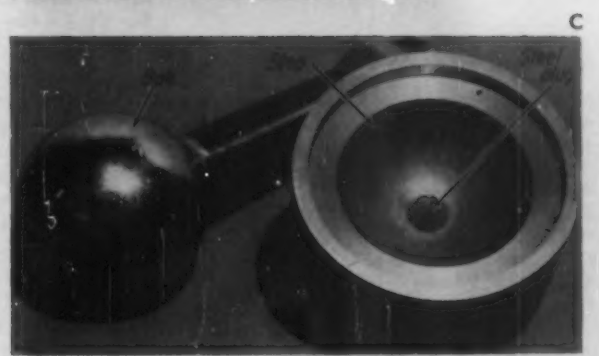


Simulator's job . . .
is to determine design parameters for control of space vehicles that have to rotate freely around a point in roll, pitch and yaw. The methods used to control attitude of the vehicle include use of reaction jets and rotating masses which produce gyroscopic effects. The requirement of pivoting around a point reduced the choice of a bearing design to a ball and socket.





Ball and socket . . .
(A) support the entire simulator, during operation and permit it to maneuver with minimum restraint. Using 300-psig air pressure, an area of 16.7 sq in. is required to support 5000 lb. This calls for a 4.6-in. ball; however, a 5-in. ball (B) is used so that the projected area of the step provides a load bearing area when there is no pressure on the bearing. Effective area of the 5-in. ball is 17.1 sq in. and a pressure of 296 psig is required to support the 5000-lb load. Air consumption with a 2500-lb load is approximately 1.6 cu ft/min. at 150-psig pressure. The steel plug (C) in the aluminum socket prevents elastic deformation at loads over 2600 lb.



PS . . . Both ball and socket bearing are formed on a tracer lathe. The ball is then ground and handlapped with cast iron laps. Next, ball and socket are lapped together to get 90% contact on the socket surface and 100% contact on the step. The step is formed by chemical milling the socket, removing 1.1 mils of aluminum. After the ball is nickel plated, it is lapped into the finished socket. Simulator and air bearing are produced by Boeing Airplane Co, Seattle. Bearing was designed by Boeing researcher C. R. Adams.

a basic building block for control-system intelligence . . .

PACKAGED NOR-LOGIC CONTROL

THE NOR—analogous to a multiple-input electrical relay—can be combined with other devices to perform almost any logic function. Here's a guide to designing circuits with transistor-type NORS . . . with an automatic welding machine as an example.

CHARLES F MEYER, *project engineer*
Industrial Controller Div, Square D Co

The NOR—a multi-input, single-output logic element (see "What is a NOR," facing page)—comes close to being a universal building block from which all other logic functions can be derived. It has two states—ON and OFF—and can directly or indirectly do all of the simple thinking for a machine . . . except TIME-DELAY and RETENTIVE MEMORY.

But what is this so-called "logic"? Applied to electrical controls, it is just a symbolic way to develop and represent all the circuit principles, answering such questions as: On or off? Now or later? "Static" logic is that achieved with electronic and solid-state devices—such as NORS—that have no moving parts.

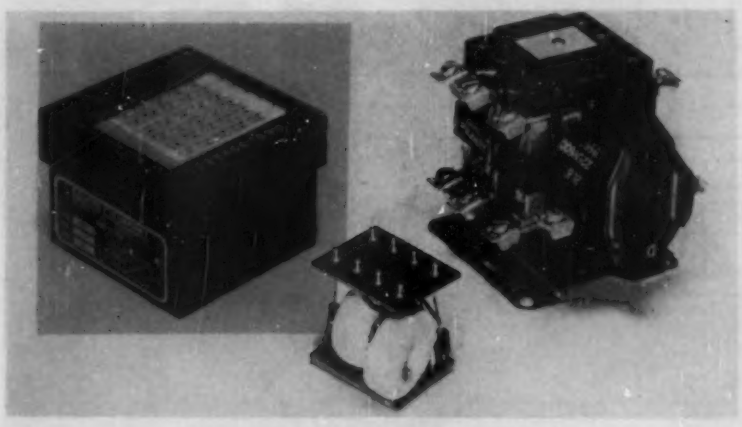
Transistors have the type of ON-OFF response needed for NORS. Magnetic cores are not as directly adaptable for that particular function. Also, transistors keep NORS very small and make them extremely fast in response—hundreds of times faster than ordinary relays and magnetic cores. And recent availability of matching power supplies, signal converters and amplifiers will make them easier to use. There are no moving parts, nothing to wear out. Their life can therefore be long—particularly when the element is encapsulated to keep out dust, corrosive gases and vapors.

NORS are not new—several manufacturers package them in one form or another. However, their ultimate potential as a do-it-yourself logic element has only begun to develop.

But there are drawbacks. For small systems, transistorized NORS might cost more than conventional electromechanical relays. This is because the cost of auxiliary equipment—power supplies, etc—needed for NORS is a high percentage of the total cost unless many NORS are used in the circuit. Furthermore, a NOR has a low power level—less than 1% of that for a conventional control relay—and its output signal must be amplified to operate a power relay.

(TEXT CONTINUED ON PAGE 50)

What Is a NOR?



Transisterized NORPAK at left has similar function to electromechanical relay (right) and magnetic core (in front) . . . its simple logic function is to switch ON or OFF depending on input signal. But it can pack more elements in the same volume. Each module (lettered) with 10 terminals (numbered) is one NOR. Block shown has 6 NORS — module A is the voltage-bus needed for energizing all NORS within the block. Total block volume is about 15 cu in. A 20-module NOR block is also available.

■ NOR is a coined word for a logic-control device that has an electrical output only if all the electrical inputs are zero. If any input exists, then the output becomes zero. It is essentially a multi-input NOT (see table of logic functions).

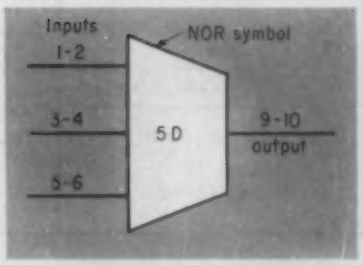
The NOR-logic concept has been experimented with for years, being called by various names—such as inverter and OR-NOT. The term NOR is derived from this statement (for a 2-input version): "There will be an output if neither one input NOR the other is receiving a signal."

Several manufacturers already offer versions of the NOR. The NORPAK—a version by Square D Co—is transistorized to conserve space, and has companion auxiliaries such as power supplies, signal converters and amplifiers (*PE*—June 8, '59, p 45). The on-off characteristics of the transistor are suited to the digital logic required by a NOR—a voltage means an output, absence of voltage means no output. Voltage variations are not a problem. Even though the collector voltage may drop to one-half value when the output is used to signal additional NORS, it is still a measurable potential and satisfactory. The no-output state will always be a fraction of a volt.

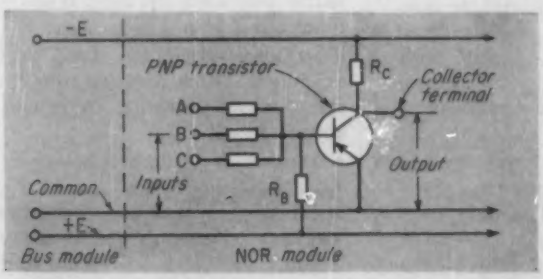
AMP taper pins, used for the NOR module terminals, are a semipermanent way to attach leads to each NOR. The pin is inserted with a special tool. Removal is made by twisting, but many insertion-removals are possible without damage.

The output from one NOR can drive up to 4 other NORS . . . or a mixture of up to 4 NORS, MEMORIES and TIME DELAYS. The loading is limited to 4 elements because current flow causes a voltage drop through the collector resistor, reducing output voltage below the acceptable 50% value. A special power-NOR, designed with lower collector resistance, will drive up to 10 elements. But then the current carried by the transistor during its conduction state—at zero collector output—will be greater from the power supply.

Although NORS are designed for versatility, and can perform all the basic logic functions except TIME DELAY and RETENTIVE MEMORY, they are not used where simpler logic elements will work. For example, diodes are less expensive than NORS for making ORS. For that reason, OR blocks—with diodes—are also available. ■

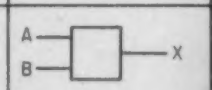
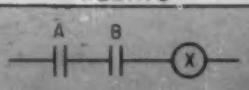
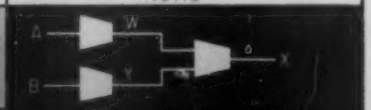
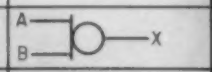
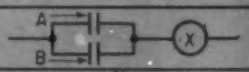
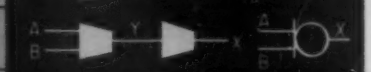
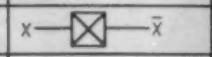
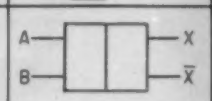
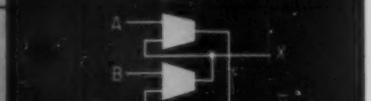
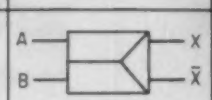
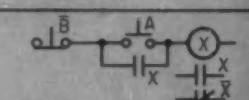
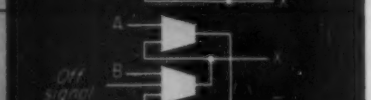
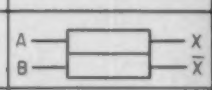
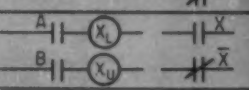
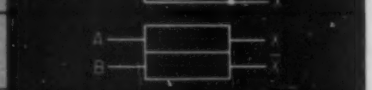
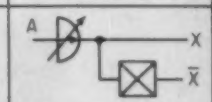
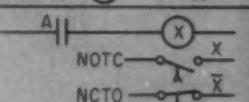
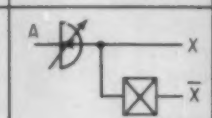
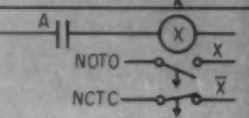


New NOR symbol recommended to NEMA is wedge-shaped. Designations on this 3-input version simplify cross-identification: schematic diagram, wire table and NOR terminals. Two terminals — shorted together—are provided for each input and output.



3-input NOR here is based on PNP-type transistor in common-emitter connection (common to input and output). Operating voltage is negative (−E) for collector resistor R_C; the three inputs must also be negative. Temperature stabilization at temperatures up to 140 F is achieved with a positive electrical potential applied to the transistor base through a series resistor R_B. When all inputs are zero, there is output, −E, at the collector terminal because the transistor in that state is nonconducting. With input at A, B or C, output at collector becomes effectively zero (actually a fraction of a volt), because the transistor saturates and becomes a conductor.

Logic-function Symbols

FUNCTION	SYMBOL	EQUIVALENTS	
		RELAYS	NORS
AND			
OR			
NOT			
MEMORY		No relay equivalent	
OFF RETURN MEMORY			
RETENTIVE MEMORY			
TIME DELAY AFTER ENERGIZATION			
TIME DELAY AFTER DEENERGIZATION			

What about NORS vs those static-control packages already on the market, containing complete, single-function logic circuits (AND, OR, NOT, etc)? The answer depends on the application. A single-function circuit lacks some versatility: A different unit is needed for each function. The NOR is basic, allowing many combinations of functions with relatively few types of elements. However, a different type of thinking is involved.

Designing with NORS

Everything from trial and error to Boolean algebra can be the basis for good circuit design with NORS, as it is for any other static-control elements. In general, all methods fall into one or both of these broad categories:

- Conventional relay-circuit design—converted to NOR-logic symbols by first replacing series circuits with ANDS, parallel circuits with ORS, and holding circuits with MEMORIES. Conventional relay circuits can also be expressed in switching-algebra terms, prior to conversion to the simplest NOR-logic solution.
- Basic logic design, using AND, OR, NOT, MEMORY and TIME-DELAY concepts—see table of **Logic-function Symbols** based on NEMA (National Electrical Manufacturers Association) standards. The example on p 52—for a welding machine—is a circuit developed directly from a written sequence of operations.

For either category—conventional or basic logic—the conversion to NORS requires understanding of these "truths":

AND—As the table shows, inputs at *A* and *B* are required before there can be an output at *X*. With NORS there will not be an output at *X* unless both *W* and *Y* are zero; and *W* and *Y* cannot be zero unless there are inputs at both *A* and *B*. Also, there can be more than two inputs: NEMA defines AND as a device which produces an output when every input is energized.

OR—An input at either *A* or *B* will result in an output at *X*. NEMA states that an OR produces an output when one input (or more) is energized. In table (above) the alternate symbol at right is a diode.

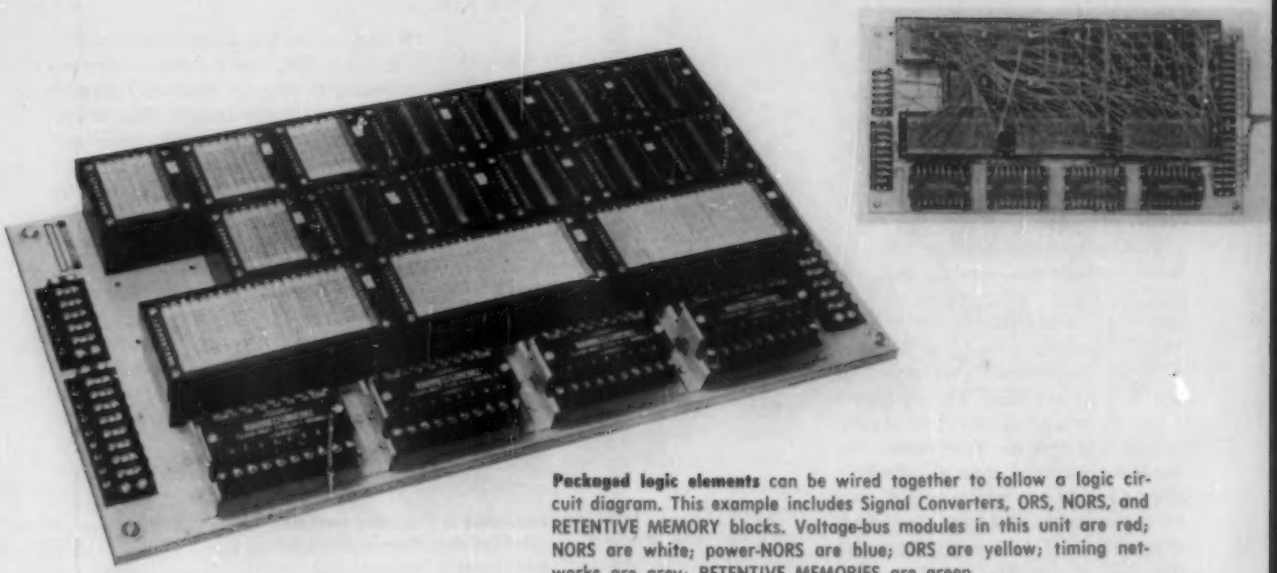
NOT—If there is an input at X, there will NOT be an output at X-bar. NEMA states that a NOT produces an output only when the input is not energized. The NOR is inherently a NOT.

MEMORY—There are three types—based on NEMA definitions. Each MEMORY type is a device which retains the condition of output corresponding to the input last energized . . .

- MEMORY . . . retentive as long as power is maintained.
- OFF-RETURN MEMORY . . . retentive except that it returns to the OFF condition upon interruption of power.
- RETENTIVE MEMORY . . . retentive regardless of system interruptions.

MEMORY requires feedback to maintain output when NORS are used. It works like this (using the digital nota-

PACKAGED NOR-LOGIC CONTROL *(CONTINUED)*



Packaged logic elements can be wired together to follow a logic circuit diagram. This example includes Signal Converters, ORS, NORS, and RETENTIVE MEMORY blocks. Voltage-bus modules in this unit are red; NORS are white; power-NORS are blue; ORS are yellow; timing networks are grey; RETENTIVE MEMORIES are green.

tions 1 and 0): Assume a momentary signal (1) at A. Consequently X-bar output is 0, lower input to bottom NOR is therefore 0, and output X becomes 1. The output X is also the lower input to the top NOR, thereby maintaining the necessary 1 at that input. Input A can thence be removed without altering outputs X and X-bar. A momentary input at B exactly reverses the state of the MEMORY: output X becomes 0, X-bar becomes 1.

OFF-RETURN MEMORY using NORS requires that one input receive a momentary signal from the OFF terminal on power supply after the power comes back on, returning output X to the 0 condition. One OFF signal can be shared by all OFF-RETURN MEMORIES in a system.

RETENTIVE MEMORY is not possible with transistors alone. Transistors do not have the retentive feature of a conventional electromechanical latching relay which retains the last position mechanically despite all circuit interruptions. However, a NOR can acquire that retentive feature if a magnetic core is added—the remanent (residual) flux density of nickel-iron square-loop core material plus a bias winding will do it. The core becomes saturated or unsaturated, depending on the last energized state of the RETENTIVE MEMORY. When power is lost and returns, the core winding will absorb (or pass) a gate voltage if the memory was previously OFF (or ON).

TIME DELAY is a special-purpose component, and can have many forms. The two that NEMA defines are: "TIME DELAY, ENERGIZING," which produces an output (after a definite intentional time delay) when the input is energized; and "TIME DELAY, DEENERGIZING," which removes the output (after a definite intentional time delay) when the input signal is removed. Variations are TIME DELAYS that produce an output when input is removed, and vice versa.

With NORS, which have no inherent timing characteristics, a timing network must be added. This network can include a fixed capacitor, variable rheostat, and a small neon light. Snap action—a requirement for digital systems—occurs when firing voltage on the capacitor is reached, ionizing the neon light. The power supply should provide up to 85 volts for that purpose. Standard delay times are from 0.2 to 8 seconds—but up to 3 minutes is possible. Nominal variation in delay time is ±30%, but repeat accuracy is about ±1% at stable ambients, −5% at temperatures from zero to +60C. Reset time is about 0.01 sec.

The NOR circuits shown are designed specifically for Square-D NORPAK elements; variations are possible, of course, if other makes are chosen.

Other elements important to logic are **power supplies, pushbuttons, limit switches, signal converters,** and **amplifiers.** Power supplies (also called power drivers) are energized by line voltage—usually 115 vac, +10%, −15%. They transform and rectify this 115 v to the levels required for the logic packages. Typical requirements for logic packages are: 130 v dc for signal converters; 85 v

PACKAGED NOR-LOGIC CONTROL (CONTINUED)

(regulated) for TIME DELAYS; lower voltages—+20 and −20 v dc—for NOR packages; bias and gate currents for RETENTIVE MEMORY blocks. Power drivers for neon indicator lights are also available. These lights may be attached to any NOR to visually monitor its operation.

Pushbuttons and limit switches are usually electromechanical, but can also be static. One commercial example of a compatible static limit switch (proximity type) is Mag-eye.

Signal converters. Two types—ac and dc—are available. The dc type is a simple voltage divider. The driving potential, 130 v dc, that powers the converter can break through oily films, dirt and corrosion which might form on the contacts. An input signal from a conventional 115 v ac line operates the ac converter, and the output can drive numerous static elements.

Amplifiers raise the energy level of a logic signal so that it can do some work—such as operating an electromechanical motor starter or solenoid valve. Transistors have proved dependable as amplifiers for logic circuits, when voltages are low.

REPRINT COPIES of this report are available for 25 cents each by addressing Readers Service Dept., Product Engineering, 230 W 42nd St, New York 36, NY.

EDITOR'S NOTE: Switching-algebra and other aids to logic design of static and electromechanical circuits are covered in these previous articles:

Switching-logic Functions, Aug '57, p 196, introduces logic principles and describes in detail a riveting-press control that uses them.

Simplifying Relay Control Circuits, Nov '56, p 162, explains switching-algebra and the meaning of logic symbols.

Transistors, the Six Basic Types, Aug 3 '59, p 42, has simplified sketches showing basic construction methods and how they influence performance.

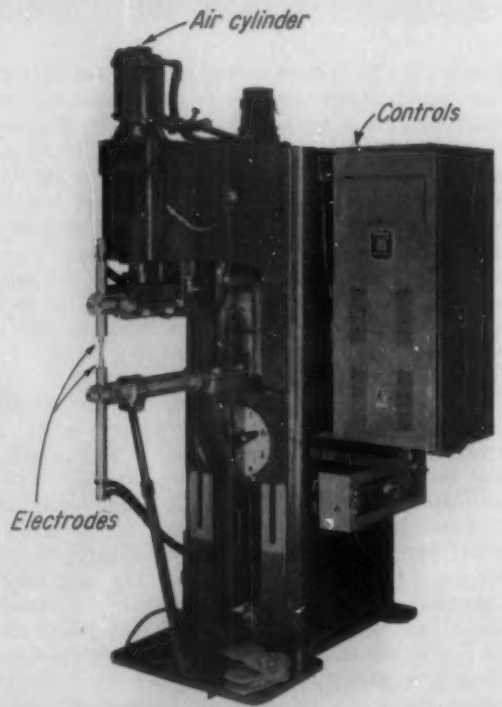
COMING SOON—A roundup article that compares all packaged-logic systems—including electromechanical as well as solid-state and magnetic controls.

EXAMPLE—

■ Purpose of the control is to close the electrodes, apply proper squeeze pressure, trigger the welding current, shut it off at the correct time, hold the work until the metal solidifies, and open the electrodes. This involves precision timing as well as a definite order of events, as can be seen in the sequence table. The logic portion of the circuit is described schematically in three steps on the next page:

A manually operated pushbutton starts the entire sequence—only momentary contact is needed. A pressure switch prevents weld current from

Resistance spot-welding machine described in working example has transistorized controls that determine proper sequence and timing of electrode movement and current.



Logic circuit for welding machine

flowing unless air pressure is high enough to assure proper electrode pressure; and a toggle switch (Weld, No-weld) allows choice between a complete cycle with welding, or one without.

The first of two output devices—a solenoid air valve—controls an air cylinder (see photo) that moves the electrodes. The other output device—the weld relay—triggers the welding-current contactor. At the end of "Hold" time, all timers are reset in preparation for the next cycle—which is initiated manually as before.

STEP 1–BASIC LOGIC DIAGRAM. Because the **start switch** is closed momentarily, a MEMORY ("A") is included to retain the signal. Output of MEMORY "A" initiates the **squeeze timer** (a TIME DELAY AFTER ENERGIZATION device), and is amplified to operate the **solenoid air valve.** Back pressure in the air cylinder (not shown) operates the **pressure switch** that energizes lower input to AND unit "B." When squeeze time ends, the **squeeze timer** output energizes the upper input to AND "B," which then has an output. That output starts the **weld timer** (TIME DELAY AFTER ENERGIZATION) and energizes center input to AND "D."

If the **weld, no-weld** switch is closed, then all inputs to AND "D" will have been energized (upper input is already energized because NOT has an output until the timer times out) and there will be an output. That output is amplified and operates the **weld relay,** starting the weld current. Weld current flows until the **weld timer** times out, energizing NOT "C," removing upper signal from AND "D," opening relay. The **hold timer** (TIME DELAY AFTER ENERGIZATION) is started at the same time, and after its delay, turns off MEMORY "A," thus deenergizing the solenoid valve. All time delays are reset, and the sequence can be initiated again within several millisec. Total sequence time for a typical operation is about 1 sec.

One necessary provision is that the start switch not be held closed during the reset interval. Additional circuitry (not shown) could overcome that limitation.

STEP 2–NOR EQUIVALENT CIRCUIT. Without changing any basic logic function, the NOR elements have been substituted for the NEMA basic symbols. Each timer chosen will start timing when the signal at its input (output of the integral NOR) is zero, and will give a pulse output of short duration when it times out. The integral MEMORY retains its output even after the input signal is gone. Reset occurs when the NOR has an output again.

STEP 3–FINAL SIMPLIFIED CIRCUIT. Elimination of redundancies, and full utilization of outputs, will reduce parts and costs. Here are typical examples.

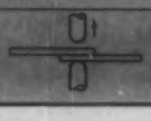
Duplication of output signals. The output from each NOR labeled "I" in Step 2 is identical to the output of the upper NOR in each preceding corresponding MEMORY. Those NORS therefore have been removed in Step 3, and the output is taken from the upper NOR of the MEMORY instead.

Double negatives. Two NORS tied in series cancel out. One such double NOR (labelled *II*) has been removed in Step 3.

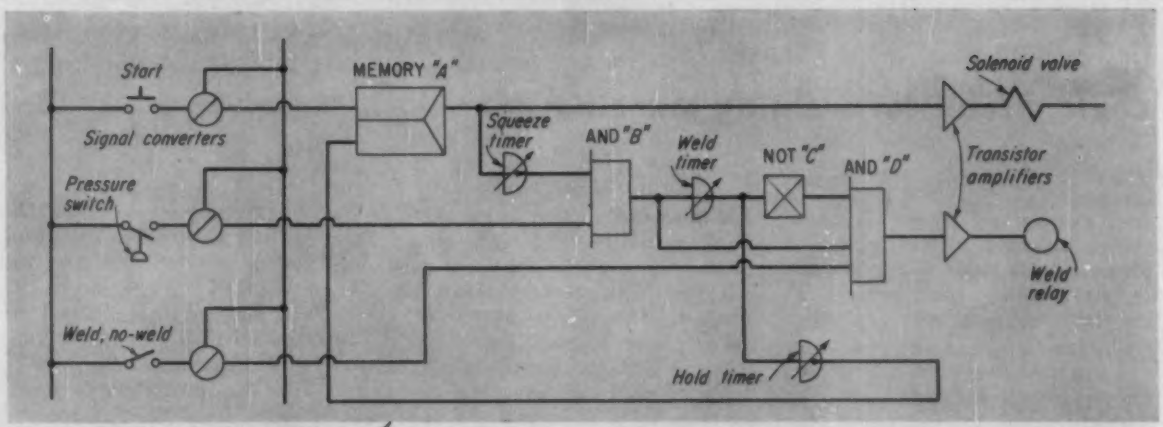
Duplication of function. The NOR labelled *III* in Step 2 is driven from the same NOR ("E") as the NOR in

(CONTINUED NEXT PAGE)

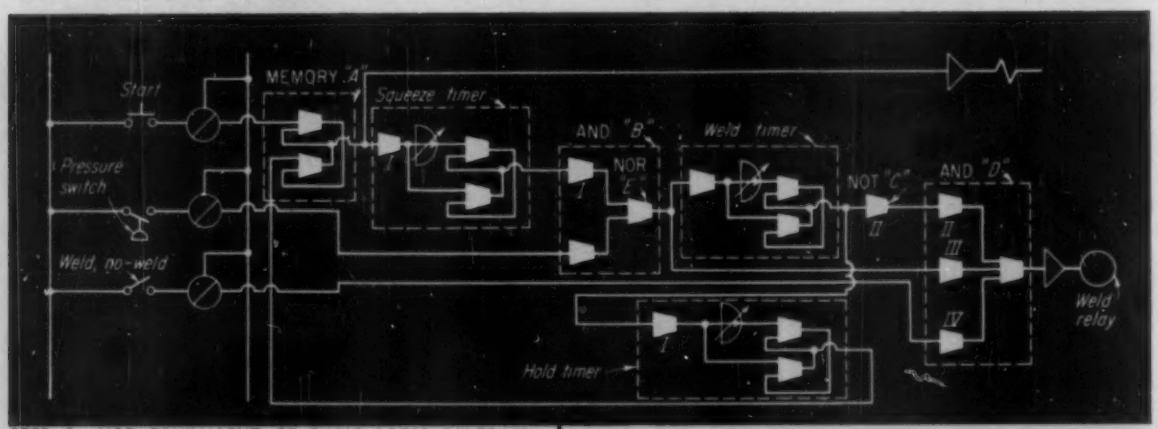
Sequence of Control for Welder

Electrode position	Control action
	1 Close start-switch (momentary) a - squeeze timing starts b - solenoid valve operates c - electrodes close d - pressure switch closes
	2 Squeeze timing ends a - weld timer starts b - weld relay picks up c - weld current flows (if the weld, no-weld switch is on) 3 Weld timing ends a - hold timer starts b - weld relay drops out c - weld current ends
	4 Hold timing end a - all time delays reset b - solenoid valve deenergized c - electrodes open

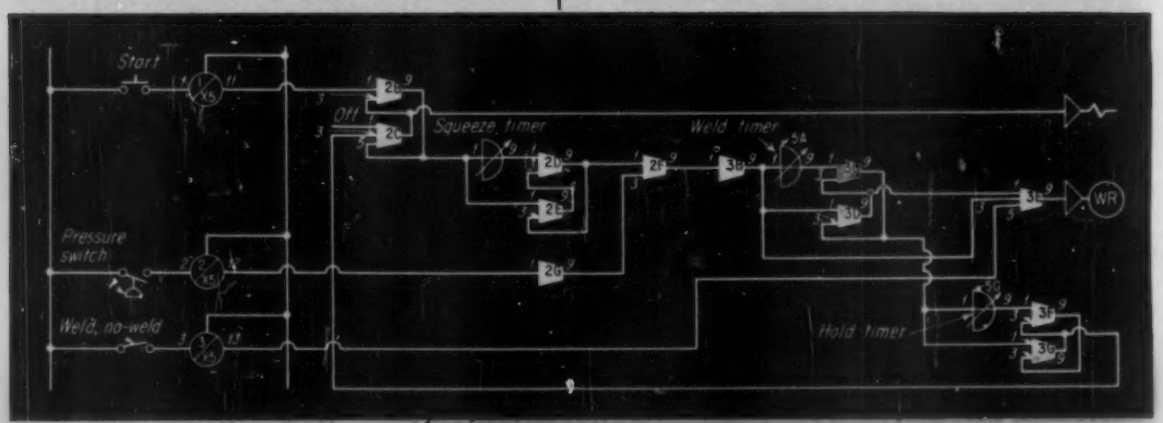
Circuit-schematic for Welder Control in Example



STEP 1—BASIC LOGIC DIAGRAM



STEP 2—NOR EQUIVALENT OF BASIC LOGIC DIAGRAM



STEP 3—FINAL SIMPLIFIED CIRCUIT

the weld timer. Therefore NOR *III* has been removed. The signal is taken instead from the output of the NOR in the weld timer.

Unused contacts. If the normally closed poles of the pressure switch and the weld, no-weld switch are available, the lower NORS of AND "*B*" and AND "*D*" are not needed. For this example, NOR IV has been removed.

From an original total of 19, the NORS have been reduced to 12. The next step—not shown here—would be to arrange the logic blocks to keep wire runs as short as possible. A technique for determining best wiring arrangement is described in "Punched Cards . . . Answer to Wiring Woes," Jan. 20 '58 p 58. The components in Step 3 have consistent numbers and letters for ease in identification.

The final control should include spare NORS, for corrections and later modifications if needed.■

a how-to

cheaper prototypes from

ONE-SHOT INVESTMENT CASTINGS

These one-of-a-kind investment castings look like production parts, are usually faster and less expensive than one-piece machinings or welded-up assemblies. The materials cost little, are readily obtained, easy to work with—6 illustrated steps show how to make casting from wax pattern.

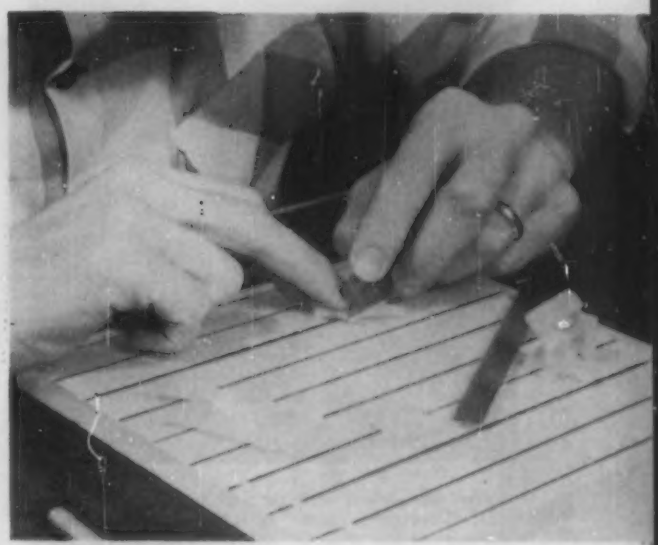
EPH KONIGSBERG, *development engineer*
Transducer Div
Consolidated Electrodynamics Corp

Even when a production drawing specifies casting the production part, the prototype is usually machined from solid stock or welded together from smaller pieces. To cast the prototype would normally require expensive patterns and take more time and money than is generally practical. But there is an exception—investment castings poured in a plaster mold, previously formed around an inexpensive, easily constructed wax pattern. This way, complex shapes can be made on a do-it-yourself basis from low-melting alloys. Or the wax pattern can be sent to a commercial foundry where it will be reproduced in stainless steel or one of the other common investment-casting metals.

These castings have additional advantages over machined parts and weldments. They reproduce all fillets and rounded corners and give an accurate, durable representation of how the production part will look. They point up weaknesses in the design before money is spent on production tooling. They help discover foundry problems that were not apparent from the print, and assist vendors in quoting prices for the finished part (some drawings are more complicated than the parts they depict). If the prototype casting is made from the same materials that will be used in production, it can help predict how the production part will react to machining, heat treating or stresses.

Because the method is easy and relatively inexpensive, it is also applicable for making parts to plan and prove out expensive dies or special production machines. It is often more practical to investment-cast prototypes of forgings, stampings, deep-drawings, and complex parts than to make them by machine.

The six steps from raw material to finished casting begin with the photo at right.



1 Cut Components of pattern from wax stock with a razor blade. In most cases, assembling a pattern from pieces is faster than carving it from a single piece of wax. Wax rods and sheets of various thicknesses can be purchased from dental supply houses.

Wax is the most common material for investment-casting patterns and easiest to work with. Patterns can also be made from polystyrene. Sheets, 1 ft square, can be purchased in small quantities from radio-parts suppliers (or it may be more convenient to cut pieces from common plastic items such as old tote boxes or parts containers). Polystyrene is not as fragile as wax, is easily machined, can be glued together with a solvent such as carbon tetrachloride or acetone.

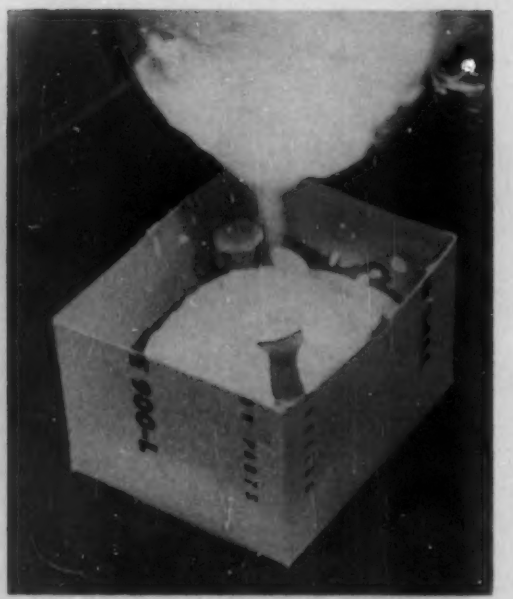
(CONTINUED NEXT PAGE)

2 **Weld wax parts together** by passing a thin, heated blade through the joint. A small soldering iron connected to a variable transformer works well. Grind the tip of the iron to a narrow blade and adjust the voltage so that the blade melts the wax readily but does not cause it to smoke.

Enough wax should be melted in each joint to give a visible fillet. When too small, fillets are built up by adding wax. This can be done two ways: Either place a small rod (made by rolling a piece of wax between the fingers) in the corner of the joint and melt it with the blade, or use the hot blade to transfer wax to the joint. To transfer —place the hot blade in a piece of scrap wax. Capillary attraction will pull wax high up on the blade. When the blade is touched to the fillet-deficient joint, the wax will run off.

The sheet wax does not limit the patternmaker to flat or rectangular shapes; with ingenuity, a variety of forms can be assembled. As shown here, cylinders can be fashioned from a sheet wrapped around a mandrel and joined with a butt weld.

When the pattern is complete, attach gates and riser as in conventional foundry practice.



3 **Cover the pattern** with an ordinary plaster of Paris mixture: three parts plaster to two parts water. This is thin enough to flow smoothly, yet not so thin that it won't set in a reasonable length of time. Bubbles of entrapped air should be removed from the mixture by putting it in a vacuum chamber before and after pouring.

Before pouring, dip the pattern in the plaster to get an even coat on all surfaces. Tap the pattern lightly or agitate it to break up any air bubbles that may have formed between wax and plaster. When this preliminary coat begins to harden, place the pattern in a cardboard box, supporting it on a hardened plaster button to keep it at least ¼ in. from bottom of the box. Plaster can then be poured around the pattern up to the level of gates and risers.

4 **Melt the wax** out of the cavity by placing the inverted mold in an oven or over a gas burner. But be careful the temperature is only high enough to melt the wax and not raised so rapidly that it cracks the plaster (thin cracks and small fissures will cause flaws in the final casting). Baking out a polystyrene pattern will require much higher temperatures (above 1100° F) and should be done under a ventilating hood so pungent vapors will not escape into the room.

When the wax has been removed, handle the mold carefully. If there is a large mass of plaster suspended in the mold by a slender neck, the mold should be oriented so that the mass hangs or stands on the neck, not placed with the neck as a cantilever to support the mass.

5 **Pour the metal** into the mold cavity. There are several low-melting-point alloys suitable for do-it-yourself investment castings. The low melting point makes casting easy and, because melting temperature is below boiling point of water, there is no danger of steam bubbles. Some common alloys, and their melting temperatures: Cerrobend (158 F), Dialoy (150-170 F) and Cerrolow (117 F). Dialoy (manufactured by M Ney Co, Hartford, Conn) can be purchased from dental supply houses for about $3/lb. Cerrobend, Cerrolow, and several similar alloys are sold by Cerro de Pasco Corp, NY, through various local distributors. All these alloys are relatively bright when first poured, but tarnish to a lead-like luster after some hours of exposure to air.

Because some constituents of these special alloys are more volatile than others, too much localized heat can change the alloy's desirable characteristics. To guard against overheating, a tin of boiling water should be used for a heat source, double-boiler fashion. Another way is to place a drop of water in the ladle to assure that the temperature does not exceed 212 F.

Plaster does not conduct heat well and consequently, the metal will cool slowly—sometimes the interior will still be molten when the metal in the gates is fully hard. Thus, be sure part has solidified throughout before breaking away mold. Cooling can be speeded by immersing the entire mold in cold water.

6 **Chip plaster** from around the casting with a hammer and small chisel (or screwdriver, as shown here). Usually the plaster will not adhere to the part, particularly if the mold has a smooth surface. But if pieces of plaster lodge in small crevices, or irregular surfaces cannot be scraped clean, a sandblaster will clean up the job without damaging the soft metal.

FINISHED CASTING

It looks like a production-cast part, is durable enough to take considerable rough handling and abuse. The soft alloys are adequate for covers (such as the one above), shrouds, housings, baseplates and other nonstructural parts. For load-bearing parts, castings in hard metals such as stainless steel can be ordered from a commercial foundry. If supplied with a wax pattern (less gates and risers—they usually prefer to do this themselves) such foundries will deliver back a finished casting for a nominal charge, starting at about $10. For hard-metal castings, lay out major dimensions of the pattern with a shrink rule.

EDITOR'S NOTE: For more on getting fast prototypes, see: **Speed Your New Product with Cast Epoxy Models,** Dec 21 '59, p 60. Cast or injection-molded plastic parts can also be simulated on a one-of-a-kind basis. Complete "Editor's Note" gives references for 8 earlier articles on modeling.

A Dozen Jobs for Low-melting-point Alloys—in next week's PE. Includes such other design applications as special soldering, imbedding, glass-to-glass sealing, encapsulating.

. . . CONTINUOUS PROCESSING -- 1965 . . .

CAMBRIDGE METAL-MESH BELTS help you beat *today's* profit squeeze—give you the low-cost production and high product quality needed for the *competitive '60's!*

Combined movement and processing means metal parts, foods, ceramics or chemicals are processed faster, more uniformly—without costly manual handling. High product quality is maintained because heat, cold or liquids flow through the belt and around the product for thorough treatment. Cambridge Belts save on operating costs, too. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs. Belts can be made heatproof, coldproof or acidproof—in any mesh, weave, metal or alloy—with any side or surface attachments.

Whether you're designing machinery for your own use, or for resale, the Cambridge Field Engineer in your area will be glad to discuss the many advantages of Cambridge Belts—from the manufacturing end to installation and service. Call him today. He's listed in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.

The Cambridge Wire Cloth Co.

DEPARTMENT P • CAMBRIDGE 1, MARYLAND

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

save time with these . . .

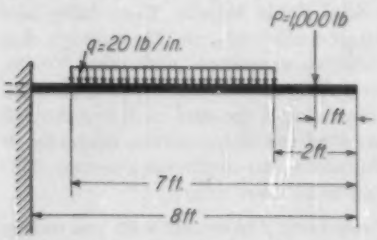
CANTILEVER DEFLECTION-FACTORS

For beams under concentrated, distributed, and bending-moment loads.

ALEXANDER BLAKE, *head, Dept of Theoretical Engineering*
LOUIS SCHERFF, *engineer, Dept of Theoretical Engineering*
Research Center, Associated Spring Corp Bristol, Conn

In the formulas contained in these charts, when a single load-type is supported by a beam, only a single deflection-factor is needed. For combined load-types, e.g. concentrated and distributed, the following example shows how two factors can be combined. If preferred, however, the separate formulas (2) and (3) can be worked out separately and the results added to give total max deflection. Addition of separate deflections is known as "superposition."

EXAMPLE: An 8-ft-long steel cantilever carries a 1000-lb concentrated load 12 in. from the end, and a 1200-lb



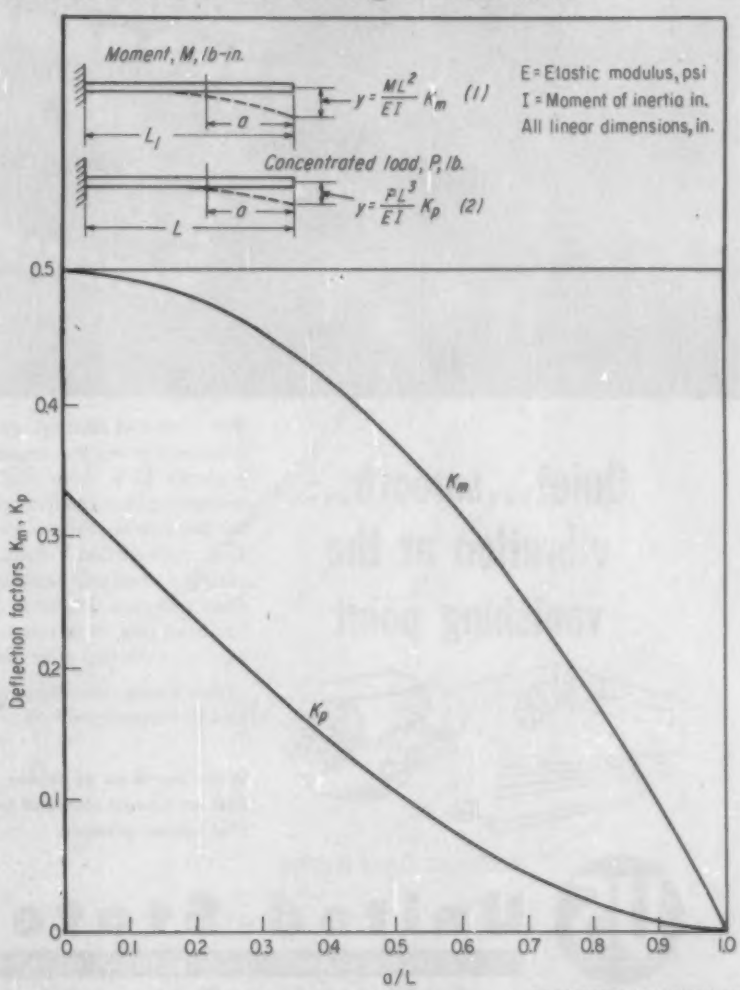
uniformly-distributed load over 5 ft, i.e. 20 lb/in. Moment of inertia for the beam is 122.1 in.^{4} Modulus of elasticity is 29×10^6 psi. Ignoring cantilever weight, maximum vertical deflection is:

$$Y = \frac{L^3}{EI}(PK_p + qLK_w)$$

$$= 0.096 \text{ in.}$$

Deflection factors, K_p and K_w are found in charts 1 (right) and 2 (next page).

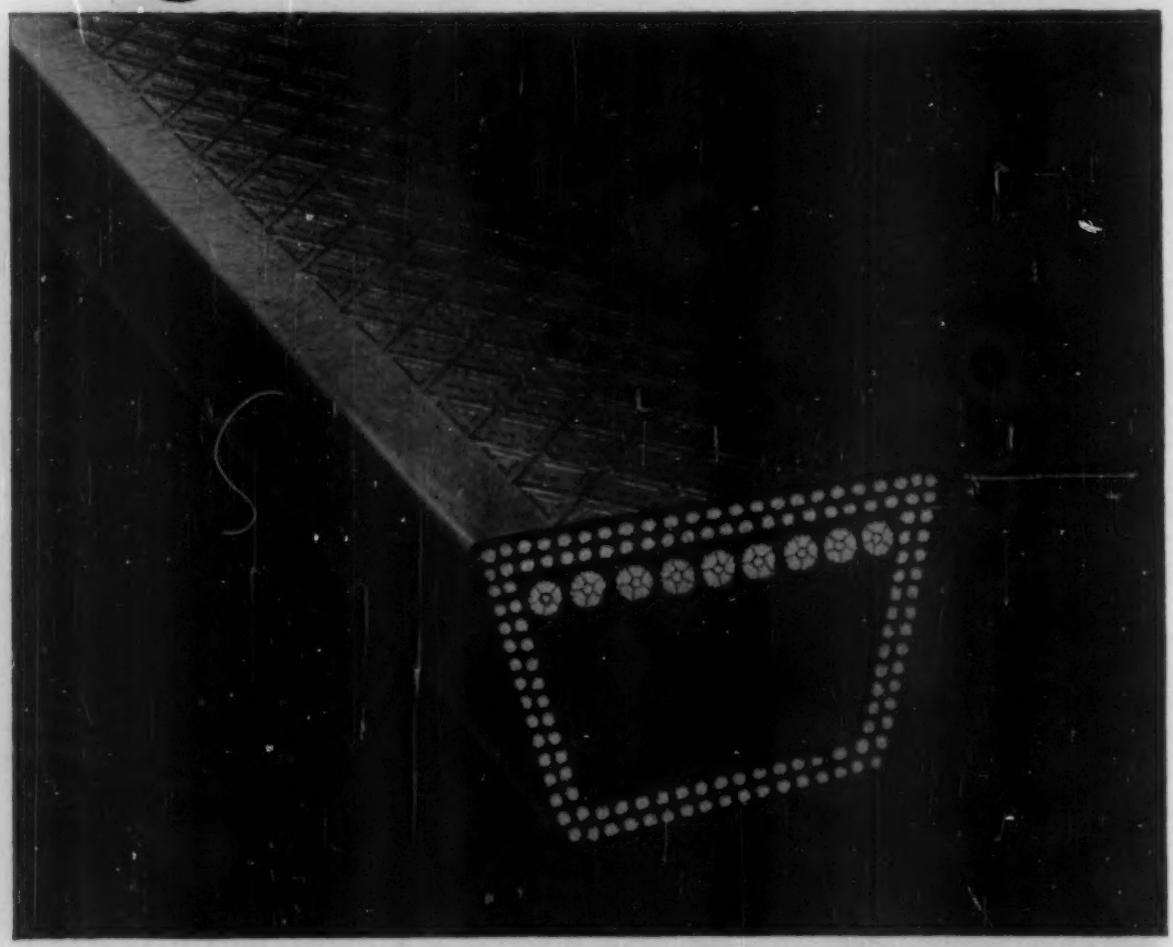
1. Concentrated and bending-moment loads



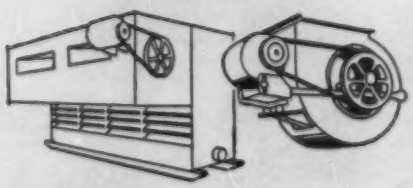
(CONTINUED ON PAGE 61)

AUTO AIRCON STEEL CABLE V-BELTS
from the Power Unlimited complete belt line

Patented curing method keeps all the steel pulling members in the same plane. They remain straight, are never wavy.



Quiet...smooth... vibration at the vanishing point



For silent and efficient operation of fans, pumps, compressors, blowers—for best power transmission in air-conditioning and refrigeration units—specify U. S. Auto AirCon Steel Cable V-Belts. These belts have everything required in a belt for air-conditioning use. They are in a class by themselves. Forget your negative experiences with other V-belts. U. S. Auto AirCon V-Belts have pulling cords of steel. A new, patented curing method and electronic tensioning of the steel cords *free this belt from vibration.* Power is transmitted smoothly, quietly, efficiently. It has been proven in rugged, automotive air-conditioning service. This belt has outlasted other belts up to 2½ times longer.

Our transmission engineers stand ready to consult with you on any and all transmission belt problems. Drop us a line at the address below.

• • •

When you think of rubber, think of your "U. S." Distributor. He's your best on-the-spot source of technical aid, quick delivery and quality industrial rubber products.

Mechanical Goods Division

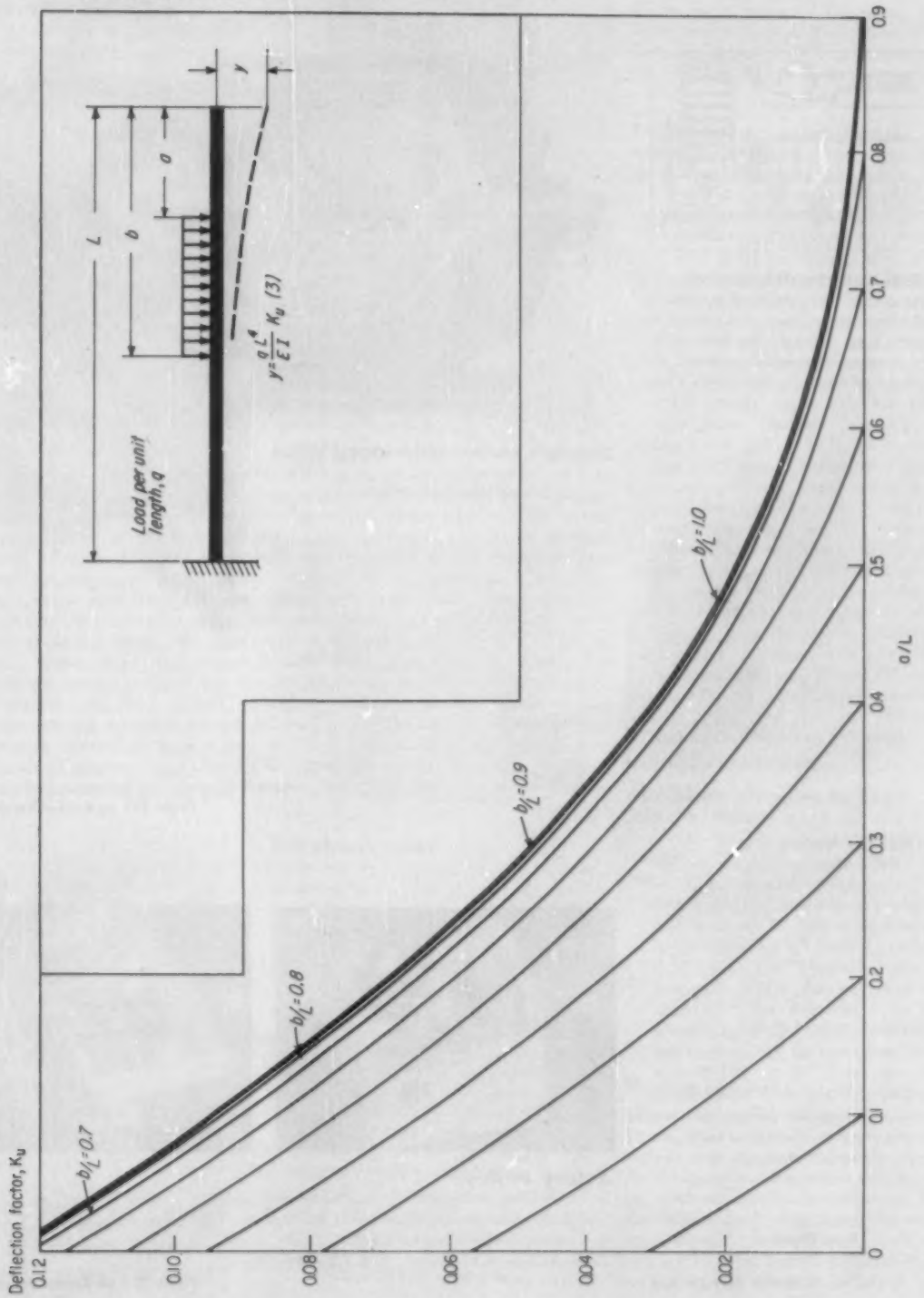
United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

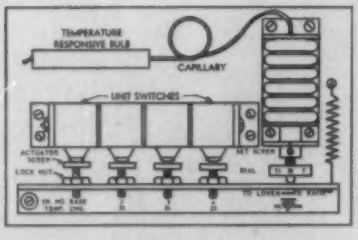
Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

CANTILEVER DEFLECTOR-FACTORS (CONTINUED)

2. Distributed load

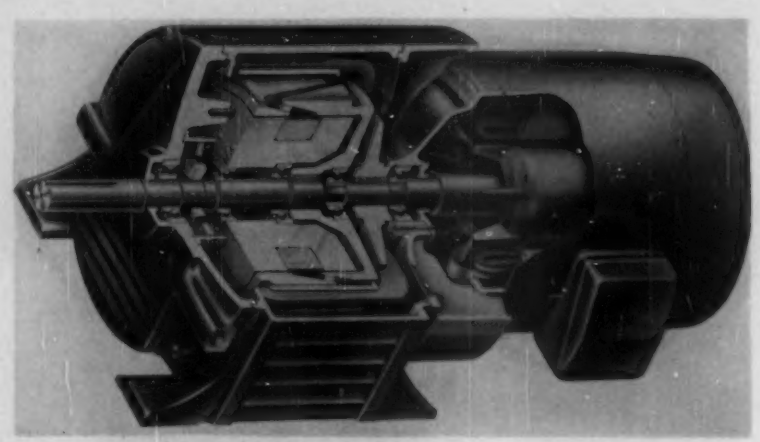


SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Thermal multiswitch control . . .
energizes two or more electrical circuits at selected temperature, time or pressure or any combination thereof. Available with 2 to 10 switches in standard model; 2 to 4 in miniature model. Separate switch provided for each stage effects SPDT switching action. Standard models offer temperature ranges of −30 to 100 F and 70 to 220 F; switching capacity of 10 amp or ½ hp or 125 v-amp, pilot duty; miniature models, 5 amp. Units are available to handle up to 20 amp. Basic components are a Xylol-filled thermal-element assembly including a temperature-responsive bulb, connecting capillary tube and bellows, responsive to temperature variations. Bellows positions contact bar actuating individually adjusted switches. **Automatic Devices Div, American Machine and Metals Inc, 714 Hillgrove Ave, Western Springs, Ill.**

Circle 300 on Reader Service Card

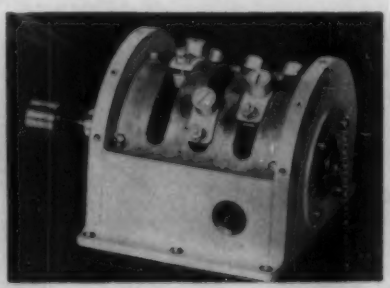


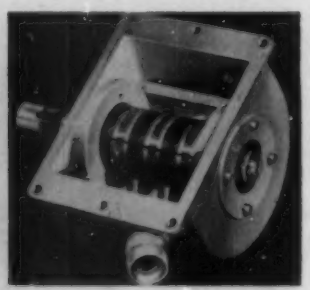
Stepless, adjustable-speed drive . . .
in 5 to 100-hp ratings, is offered as a complete package, including drive unit, control enclosure with control for both eddy-current coupling and integrally mounted ac motor, and operator's station. Drive is factory-tested as a package and prewired to facilitate installation. Input member of coupling is driven by induction motor at constant speed. Speed of output shaft is adjustable over wide range by controlling excitation of coupling field coil. Ratings through 20 hp are capable of continuous operation down to 100 rpm at rated torque, providing speed range of approximately 17:1. Standard automatic control offers close speed regulation, providing regulation of 2% of full speed on typical friction-type load. All ratings are in hp delivered at output shaft of coupling, rather than at output shaft of ac motor. Coupling design features include new bearing arrangement said to attain positive gap alignment and to simplify disassembly and reassembly. Bearing loads are reported to be reduced sharply for longer bearing life and bearing reservoirs provide continuous controlled lubrication. Coupling field coil and integral tachometer generator are stationary, with no brushes or slip rings. Windings are epoxy-encapsulated. Control enclosure elements are all front-wired. **General Electric Co, Schenectady 5.**

Circle 302 on Reader Service Card

Solenoid air valve . . .
in three- and four-way models for air service to 150 psi max, is designed for 115 v, 60 cps power supply, with continuous duty operation from +5 to −15% rated voltage. Although rated for air, many of the valves can be utilized with other fluids within same pressure range. Reported capable of cycling well over 1000 cpm. Gasketed throughout, unit is splashproof, dustproof and meets all JIC specifications. Suitable for use in 40 to 175 F with normal pressures and cycle rates. Three-way normally closed valve has $\frac{5}{16}$ in. dia orifice size; four-way, normally closed side has $\frac{5}{32}$ in. dia orifice, normally open side has $\frac{5}{16}$ in. dia orifice. Valves weigh 20 and 28 oz, respectively. Three-way valve, $18; four-way valve, $26. Both available off the shelf. **Ross Operating Valve Co, 120 E Goldengate, Detroit 3.**

Circle 301 on Reader Service Card





Rotary switch . . .
for controlling automatic cycling equipment shuts off power at end of each cycle and starts cycle automatically, unless interrupted. (Cycle can be adjusted.) Connected to customer's actuating solenoid. Breaks 3 amp at 115 v ac. **Superior Carbon Products Inc, 9115 George Ave, Cleveland 5.**

Circle 303 on Reader Service Card

Maintained-action footswitch

models include SPDT version rated 20 amp at 125, 250 and 460 v ac and DPDT unit with 10 amp rating at 125 v ac and 5 amp at 250 v ac. Both measure 3½ x 2½ x 1¼ in. **Linemaster Switch Corp, 432 Woodstock Terrace, Woodstock, Conn.**

Circle 304 on Reader Service Card

Nonconductive adhesive . . .

adheres to most metals, but has nonmetal base. Intended for watertight and oiltight applications. Specifically developed for use in electronic applications where adhesives containing metal fillers are not acceptable. With steel, it has tested up to 3000 lb tensile shear strength. Will not adhere to plastics like vinyl, polyethylene or polystyrene. 12-oz kit sells for $2. **Beetle Plastics of Crompton & Knowles, Fall River, Mass.**

Circle 305 on Reader Service Card

Miniature revolution counter

indicates shaft revolutions up to 1000 rpm and requires 1¼ in.-oz torque for dependable electrical control of machine or system operation. Repeatability is 0.0025 of dial range. For ac or dc operation, available with 11 dial ranges from 0 to 12 to 240,000 revolutions and in numerous circuit arrangements. **Automatic Timing & Controls Inc, King of Prussia, Penna.**

Circle 306 on Reader Service Card

Non-glare panel light . . .

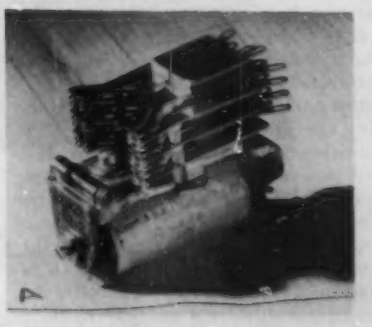
for applications that require subdued illumination is available in 6, 12 or 28 v models. Prisms control upper and lower limits of light, eliminating light spill-over and reducing eyestrain. Made to meet aircraft standards. Typical dimension is 1.5 in. over-all length with 10-32 stud mounting. List, $3.75 to $4, depending upon series. Delivery, stock to 2 wk. **Glar-Ban Corp, 110 Glar-Ban Bldg, 3807 Harlem Rd, Buffalo 15.**

Circle 307 on Reader Service Card

Manual power switch . . .

can be tripped electrically by any type of power from remotely-located control or safety device. Circuit breaker contacts are electrically isolated from coil. Consequently, a limit control, timer, malfunction detector, or overload condition in one circuit can cause tripping in another, interlocked control circuit. Power switch-control interlock has interrupting capacity of 2000 amp at 125 v ac. Available with current or voltage-sensing coil. **Heinemann Electric Co, 713 Plum St, Trenton 2, NJ.**

Circle 308 on Reader Service Card



Telephone relay . . .

is reported to have surpassed 200 million operations in 10 pulse per sec pace comparison test. Approximate size is 2 7/32 x 1 3/32 in. wide. Operates on 2 milliamp min. **Phillips Control Corp, 59-T W Washington, Joliet, Ill.**

Circle 309 on Reader Service Card

Electronic tachometer . . .

is self-contained unit and offers accuracy of better than 0.25%. Measures rpm with no mechanical or electrical linkage between instrument and rotating system component. Output can be used with any 0 to 1 millamp average reading device. Power requirement is less than 1 w; source may be 60 or 400 cps ac line or 12 v battery. **Airpax Electronics Inc, Seminole Div, Ft Lauderdale, Fla.**

Circle 310 on Reader Service Card

Printed circuit connectors . . .

for printed tape cable or printed circuit board applications are offered in two series, for 13-contact and 18-contact units. Miniature connectors have current rating of 3 amp and feature staggered placement of contacts. 13-contact series accepts 3/32 in. board or cable and can be stacked because of module design. 18-contact series is for 5/32 in. board or cable. **Electronics Div, DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.**

Circle 311 on Reader Service Card

Subminiature pilot lights . . .

achieves water-tightness by means of flat, 3/32 in. thick, neoprene gasket on shank of lens holder and 1/32 in. thick retained O-ring seal behind flange of mounting bushing. Unit measures 1 5/16 in. long and mounts from front in 3/8 in. clearing hole. Fully insulated units accommodate midget flange base incandescent lamps of 1.3 to 28 v. Cap made in transparent or translucent finish in clear or any of six colors. **Dialight Corp, 60 Stewart Ave, Brooklyn 37, NY.**

Circle 312 on Reader Service Card

Miniature pressure reducer . . .

for air or nitrogen is said to have high flow capacity. Gas at 3000 psi can be reduced to 300 psi or to any pressure between 300 and 1800 psi by selecting proper spring for the assembly. Rated capacity factor is 0.05; max capacity factor, 0.10. Operates in —65 to 200 F. 2 3/8 x 2 7/16 x 1 3/32 in. envelope and assembly weighs 8 oz. **Walter Kidde & Co Inc, Aviation Div, Belleville 9, NJ.**

Circle 313 on Reader Service Card

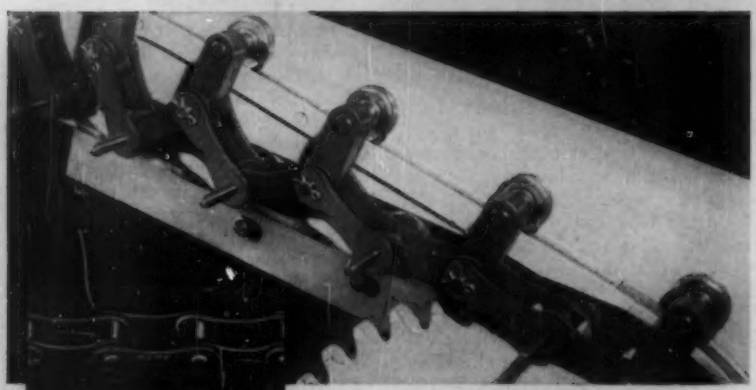
High-pressure contacts (solid silver to solid silver) . . .

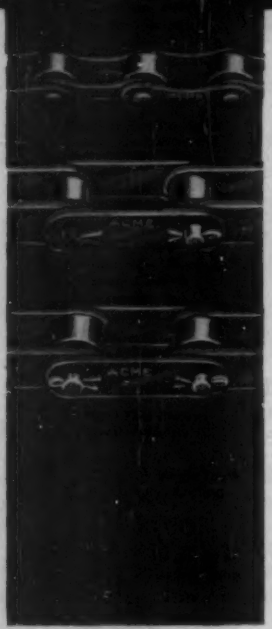
for air switches are said to permit heavy wiping action, to eliminate corrosion under adverse atmospheric conditions, and not to gall. Contacts are now available on all TG and YVH group-operated switches in firm's line. These consist of vertical break switches 7.5 to 34.5 kv (400, 600 and 1200

(continued on page 64)

AUTOMATION

WITH *ACME* DOUBLE PITCH CONVEYOR CHAIN BECOMES MORE EFFICIENT AND ECONOMICAL





Double pitch conveyor chains, sometimes known as extended pitch chains, are becoming increasingly more popular in many industries where high grade precision roller chains are required, at a lower cost than the standard series chains. This series was developed on the basis of using standard round parts of the standard series and doubling the pitch.

In addition to being applicable for slower speed power transmission drives, these chains are widely used as conveyors for the handling of materials. A standard line of attachments are available that gives this line greater versatility in reference to incorporation of cross flights, cross rods, etc., that are applicable for conveyor work.

Double pitch chains are widely used in the Agriculture Implement, Baking Machinery, Construction Machinery, Mining, Packaging, Textile industries, etc.

Call your nearest ACME Chain Distributor. He has the full cooperation of our Engineering Department.

Write Dept. 1-K. for new 100-page illustrated technical catalog including new engineering section showing 36 methods of chain adjustments.

Acme Chain Corporation
HOLYOKE MASSACHUSETTS

· COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS · DOUBLE PITCH CONVEYOR CHAINS · STAINLESS STEEL CHAINS · CABLE CHAINS · FLEXIBLE COUPLINGS · STANDARD AND SPECIAL ATTACHMENTS

amp) and center side break switches 46 to 161 kv (600, 1200 amp). Federal Pacific Electric Co, 50 Paris St, Newark 1, NJ.

Circle 314 on Reader Service Card

Extruded rod . . .

of Delrin up to 3 in. dia is now available. Thermoplastic material can be machined and fabricated on standard machine shop equipment. Garlock Packing Co, 441 Main St, Palmyra, NY.

Circle 315 on Reader Service Card

Miniature speed reducers . . .

available from stock are about ⅞ in. dia. Made to Mil Specification, size 10 frame, in ratios from 9:1 to 3000:1. Precision ABEG-5 ball bearings throughout. Max rated output torque is 35 in.-oz. Backlash through entire train is reported to be less than 30 min. measured at output shaft. Gears are cut to precision 2 or better. Pic Design Corp, 477 Atlantic Ave, East Rockaway, NY.

Circle 316 on Reader Service Card

Heavy-duty flexible shafts . . .

with 1 in. dia core shaft will transmit up to 760 in.-lb torque at 600 rpm; 1¼ in. dia core shaft will transmit up to 1650 in.-lb torque at 500 rpm. Core made of layers of wound high-grade music wire. Flexible casing is lined with oil-tempered spring steel, reinforced with wire braid and covered with oil-resistant, neoprene-impregnated fabric and abrasion-resistant rubber jacket. Square slip coupling has enough play to accommodate slight changes in length due to varying torque loads. Stow Mfg Co, 426 Shear St, Binghamton, NY.

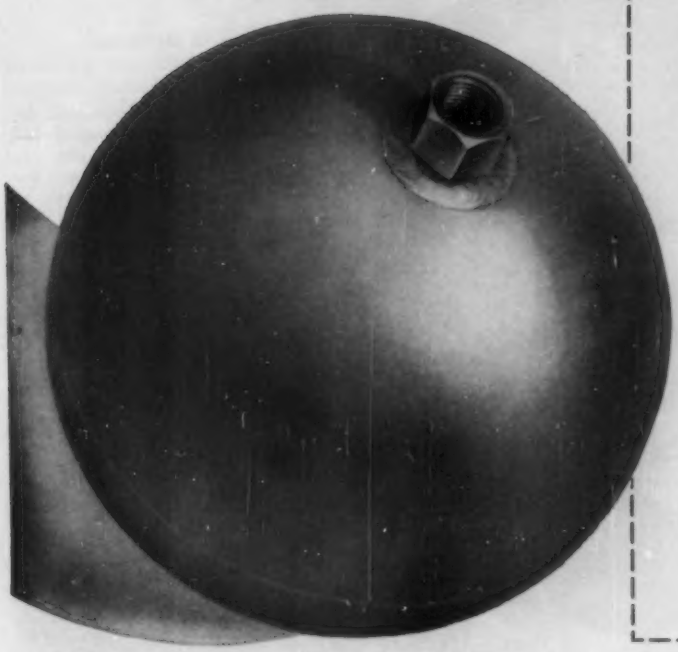
Circle 317 on Reader Service Card

Electronic control device . . .

continuously performs digital comparison of command and feedback signals and produces an error-modulated ac analog drive signal. Inherent accuracy is said to

(continued on page 66)

need floats?



Name the way you want them!

MATERIAL_____
SHAPE_____
SIZE_____
PRESSURE_____
QUANTITY_____
MORE INFO_____

*Your Name*_____
*Title*_____
*Company*_____
*Address*_____

See below for details

Fill in blanks, tear out, and mail to:
W. H. NICHOLSON and COMPANY
Wilkes-Barre, Pa.

Nicholson can deliver precision welded floats —made to your specifications—to fit your production schedule. Use the above form to tell us how you want them.

Here are the standard specs:

- **MATERIAL**—steel floats with chromium, cadmium or copper plating—with sandblast or pickled finish . . . stainless steel and Monel floats—rough-buffed, polished or with welds ground smooth and highly finished.
- **SHAPE**—spherical, elliptical, cylindrical.
- **SIZE**—from 2 inches to 14 inches diameter.
- **PRESSURE**—from vacuum to 4800 lbs.
- **QUANTITY**—as many as you need.

These high tensile strength floats have exceptional resistance to pressure and corrosion. Float halves are die-formed, with inward rolled edges—not spun, laminated or electrodeposited.

Today, thousands of Nicholson floats are in service—most as buoyancy mediums . . . many as fluid chambers and pressure vessels. Write for details about the full Nicholson line.

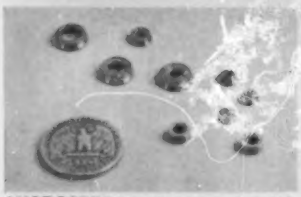
W. H. NICHOLSON AND COMPANY, 12 OREGON ST., WILKES-BARRE, PA., *Sales and Engineering offices in 98 principal cities.*

NICHOLSON
of Wilkes-Barre

Stop Overdesigning—

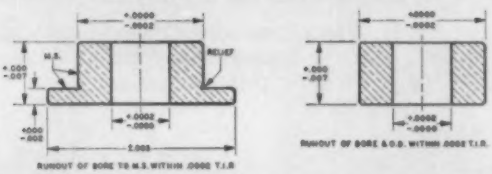
MAKE THE SHOE

FIT THE FOOT!



MICROSPIN—Northfield's new miniature precision instrument bearings. Designed for a wide variety of applications where speed and torque requirements do not justify the high cost of expensive ball bearings, but where precision instrument standards of tolerances, life, and friction must be maintained.

MICROSPIN bearings are precision-made of sintered bronze per MIL-B-5687, Type I, Comp. A, with 4% Molybdenum Disulphide. Oil-impregnated, completely self-lubricating. **Interchangeable with standard miniature ball bearings —at only ⅓ the cost! In stock—immediate delivery of production quantities!**



WRITE, PHONE for catalog-engineering data on standard and special sizes. Northfield Precision Instrument Corp., Island Park, L. I., N. Y. GEneral 1-1112

NORTHFIELD
PRECISION INSTRUMENT CORPORATION

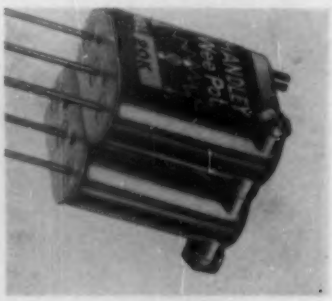
be within ½ the least significant digit or bit. One model accepts up to two 24-bit parallel binary numbers; another model up to two 24-bit parallel binary-coded decimal digits. Each digit is handled by separate transistor-equipped circuit board. Has modular construction; measures 6½ x 22 $\frac{5}{16}$ x 18 in. **Norden Div, United Aircraft Corp, 58 Commerce Rd, Stamford, Conn.**

Circle 318 on Reader Service Card

Spline drive is optional . . .

on modular clutch-brake units, when used for machine-drive applications involving heavy torsional reversals, shock loads and vibratory conditions. Now supplied with spline drives in range of five sizes, for power transmission requirements from ½ to 50 hp. **Cycledynamics Inc, 19025 W Davison Ave, Detroit 23.**

Circle 319 on Reader Service Card



Trimming Potentiometer . . .

permits stacking of 2 to 10 units. Withstands 100-g acceleration, 50-g shock and temperatures of —67 to 284 F with 1.3 w at 104 F. Small worm gear adjustment, free of backlash, delivers high friction loading; 360° wiper maintains setting under extreme temperatures and vibration. **Handley Inc, 2030 Colorado Ave, Santa Monica, Calif.**

Circle 320 on Reader Service Card

Plastic tubing insert . . .

is said to prevent rupture of PVC polyethylene and nylon soft plastic tubing when used with brass or steel fittings. Available in brass and stainless steel in seven sizes for use with plastic tube sizes from ¼ to ⅜ in. with $\frac{1}{16}$ in. wall; ¾ in. size with $\frac{3}{32}$ in. wall and 1 in. size with ⅛ in. wall. **Weatherhead Co, Fort Wayne, Ind.**

Circle 321 on Reader Service Card

High-temperature Laminates

developed for industrial use at 500 F include materials reinforced with asbestos mat and glass fabric. Both are available in sheets and strips and, for special requirements, in tube form. Flexural strengths

(continued on page 68)

Dynamic Ideas in Engineering . . .

thrive on Norton ceramic materials

Here are the "basic ingredients" in some of today's most advanced design concepts . . . Norton Ceramic Materials. Exceptionally versatile, these exciting materials are meeting operating requirements of products and processes across industry.

Norton Ceramic Materials offer design engineers a wide range of outstanding physical, chemical, thermal, and electrical properties. What's more, they provide interesting *combinations* of these properties. For example: CRYSTOLON* silicon carbide provides high thermal conductivity as well as exceptional thermal strength; ALUNDUM* aluminum oxide has excellent chemical stability in addition to good abrasion resistance; MAGNORITE* magnesium oxide offers high purity, thermal and electrical resistance; fused zirconium oxide is today's highest melting point material available in tonnage quantities and it's immune to both reducing and oxidizing atmospheres. And each product has *many* other invaluable properties.

Think of Norton Ceramic Compositions as essential components in equipment for metal and chemical processing, electrical, electronic, ceramic and nuclear applications . . . as "the answer" to literally hundreds of design problems. They're manufactured to meet highly exacting standards of purity, density, shape, size and wear resistance . . . available in granular and in fabricated form to meet *your* requirements efficiently and economically. For complete details, write for "Norton REFRACTORY GRAIN". NORTON COMPANY, Refractories Division, 220 New Bond Street, Worcester 6, Mass.

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

NORTON
REFRACTORIES
Engineered . . . Rx . . . Prescribed

Making better products . . . to make your products better

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — BEAR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

are 35,000 and 60,000 psi lengthwise for the respective materials; 25,000 and 50,000 psi, crosswise. **Synthane Corp, Oaks, Penna.**

Circle 322 on Reader Service Card

Solid-state time delay . . .

switching device handles up to 50 amp without arcing, contact damage, radio interference, audible noise or vibration. Weighs 3 oz. Available in three basic types, for light duty rated up to 10 amp, for medium duty, up to 16 amp and for heavy duty to 32 and 50 amp. Max power required is 50 milliamp; standard operating voltages are 24 to 31 v dc. **Geo Harmon Co, 18232 Parthenia, Northridge, Calif.**

Circle 323 on Reader Service Card

Enclosed precision switch . . .

has 2-way adjustable roller-lever actuator. Actuator arm can be adjusted through 240° around its shaft and actuator bracket can be rotated about plunger and locked in any of eight positions, 45° apart. Basic switch is UL-listed at 20 amp, 125, 250 or 480 v ac. Can also be furnished with hp ratings of ¾ hp, 125 v ac and 1½ hp, 250 v ac. **Unimax Switch Div, W L Maxson Corp, Ives Rd, Wallingford, Conn.**

Circle 324 on Reader Service Card

Silicon-controlled rectifiers . . .

for applications requiring load currents up to 16 amp and blocking voltages from 20 to 200 v, such as static switching, dc motor control, variable and regulated dc power supplies, welding control, ignitron firing and similar switching uses. Units are hermetically sealed and have over-all height of 1.615 in. max. Approximately $38 to $80 each in quantities of 10 to 50. Delivery, 6 to 8 wk. **International Rectifier Corp, 1521 E Grand Ave, El Segundo, Calif.**

Circle 325 on Reader Service Card

Electronic delay timers . . .

perform after deenergization or on energization. Available in time ranges from 0.05 min. to 2.3 min. max. DPDT, two normally open and two normally closed contacts are provided as standard with ratings of 5 amp, 115 v ac; 5 amp, 28 v dc. Supply voltage of 115 or 230 v, 60 cps, may be used. Furnished in open NEMA 1, 4, 7 or 12 enclosures. **Gemco Electric Co, 25685 W 8 Mile Rd, Detroit 40.**

Circle 326 on Reader Service Card

Hydraulic motors and pumps . .

are high-energy, low-friction units rated for 3000-psi system pressures. Reported advantages are 96 to 98% volumetric efficiency, 92 to 93% over-all efficiency. Standard units are suitable for use at —65 to 275 F. Weighs about 3.5 lb. Motor delivers better than 4.5 hp per lb, has rated speed of 5300 rpm and displaces 0.40 cu in. per rev. **Cornelius Co, 550 39th Ave NE, Minneapolis 21.**

Circle 327 on Reader Service Card

Nuclear delay timer . . .

can provide a burst of electrical energy at any time from a few seconds after activation to years later. Built around Krypton-85 nuclear battery and incorporating low-leakage, high-voltage polystyrene capacitor, high-reliability metal-ceramic diodes and miniature metal-ceramic voltage and current regulators, timer weighs under 1¼ lb, with volume of about 7 to 10 cu in. Operates in — 165 to 165 F. **Radiation Research Corp, 1114 1st Ave, New York 21.**

Circle 328 on Reader Service Card

Phase sequence relays . . .

offer automatic monitoring of three-phase power. If incorrect phase sequence is applied, unit prevents current from passing through to equipment. Relay contact in resting state is open, making unit fail-safe. Contact remains open when any lead or combination of leads are open and/or grounded. **Master Specialties Co, 956 E 108th St, Los Angeles 59.**

Circle 329 on Reader Service Card

Miniature instrument bearings

are said to cost one-third that of most miniature ball bearings. Made of sintered bronze with 4% molybdenum disulphide added at sintering. Available in full range of standard miniature sizes, in flanged and nonflanged styles. Dimensionally interchangeable with standard miniature ball bearings. Tolerances may be specified equivalent to class ABEC 5 or 7. From stock. **Northfield Precision Instrument Corp, 4400 Austin Blvd, Island Park, NY.**

Circle 330 on Reader Service Card

Rotary potentiometers . . .

in sizes from ⅜ to 3 in. dia offer various terminations and resistances. Either 10 or 20 output circuits are contained in 2⅝-in.-long, 392 F stainless steel, hi-temp units. Offer 200 K resistance, high resolution and noise level, withstand 40-g vibration. Shaft torque is 3 in.-oz. Adjustable from either side, self-phasing segmented units can be ganged. **Subminiature Instruments Corp, 3705 Sunnyside Dr, Riverside, Calif.**

Circle 331 on Reader Service Card

Mechanical integrator . . .

is compact, lightweight ball- and-disk-type unit. Weighs 6.5 oz. Offers disk input speed of 250 rpm max; disk input torque, no load, of 0.33 in.-oz; ball displacement of 0.750 in.; output torque of 1 in.-oz max; output-to-input ratio of 16/3 x carriage displacement. Error at max ball carriage displacement ranges from about 0.3 to 1% of local value, depending on output torque. **M Ten Bosch Inc, Pleasantville, NY.**

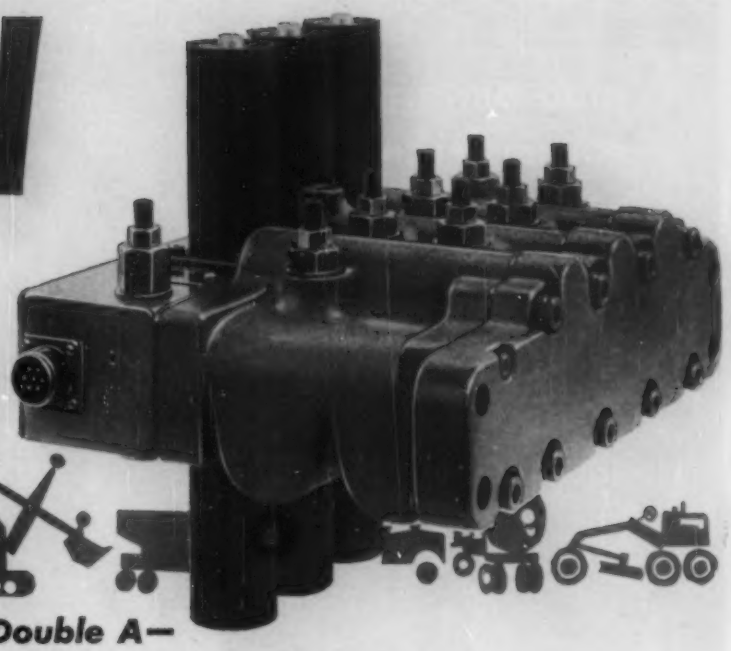
Circle 332 on Reader Service Card

Vibration meter . . .

for accurate measurement of velocity, displacement amplitude and acceleration of vibration is portable, lightweight unit. Up to six vibration transducers may be connected simultaneously and their outputs selected as desired. Acceleration, velocity or displacement are selected from function switch and read directly on mirrored meter scales. Has 5 to 10,000 cps frequency range. Accuracy is reported to be within 5%. Price is $475 FOB Houston, excluding filters, portable or rack-mounted. **Southwestern Industrial Electronics Co, 10201 Westheimer, PO Box 22187, Houston 27.**

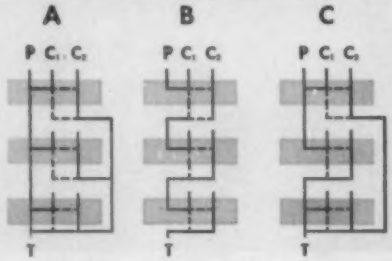
Circle 333 on Reader Service Card

NEW MOBILE VALVE



From Brown & Sharpe/Double A—

An Electrically Controlled Mobile Valve



VALVE CIRCUIT VARIATIONS

The Double A mobile valve is for service up to 2000 psi, and has a nominal rating of 15 gpm. Many valve circuit variations are possible. The two basic ones are: A. Series supply with parallel exhaust. B. Supply and exhaust in one continuous series. Many variations between the two are possible, as shown in diagram C.

Designed for modern mobile equipment applications, this Double A mobile hydraulic valve leapfrogs present day components to answer all the foreseeable needs of equipment builders—electrically controlled pilot operators—built-in flow controls over input and individual spools—plug-in type electrical hook-ups—economical multiple-spindle housings having three spools (shown above) or two spools (coming soon)—wide choice of valve circuits.

- **This valve, the first of its kind, is installed in the most efficient, economical place rather than where operator convenience dictates. It is remote controlled by 12-volt DC* oil immersed, dirt-proof solenoids (with palm button manual override) which operate matched pilot valve spools. Priced for mobile equipment sales.**
- **An adjustable, pressure compensated flow control valve is built in to provide constant flows under varying loads and engine speeds (optional). For even finer flow control, individual flow controls are available at any of the three 4-way spools (as shown above).**
- **Mobile equipment requirements are met in the Cannon plug-in wiring connectors (solenoids are all pre-wired to the connector), the straight-thread (or NTP) ports for mobile hose fittings, and the provisions for mounting the valve.**

**also 6, 18, 24, 36, 50, etc.*

Brown & Sharpe

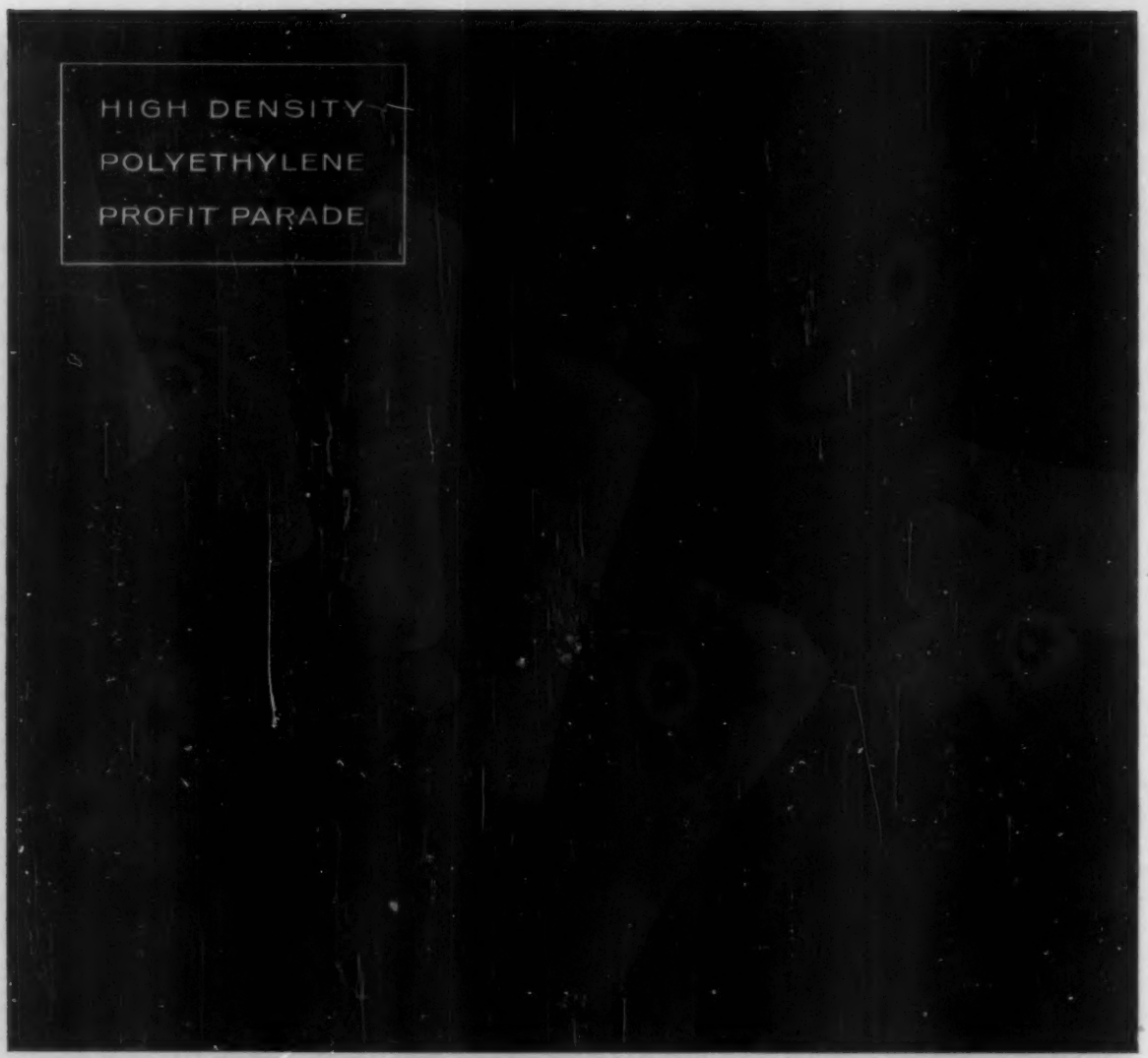
HYDRAULICS DIVISION

GEAR, VANE & CENTRIFUGAL PUMPS
DOUBLE A VALVES
GEROTOR PUMPS
POWER UNITS

PROGRESS IN PRECISION FOR OVER 125 YEARS

GET COMPLETE INFORMATION
on Double A hydraulic mobile valves.
ASK FOR VT-03-DDD sheets.

Take advantage of Double A hydraulic developments. Contact your nearest Double A hydraulic distributor. Or write to **Double A Products Co.**, a subsidiary of Brown & Sharpe Mfg. Co., Manchester, Michigan.



Plastics Development Pays Off for Hollow Products

If hollow products, parts or containers are important in your business you should know what blow molding and high density polyethylene from Grace have to offer. These dent-resistant, durable bottles by Owens-Illinois show a few of the benefits never before realized with other plastics and fabricating techniques.

High density polyethylene can be used to produce hollow objects such as these bottles that are featherweight yet remarkably rigid and strong, even in thin wall sections. Economies in production and raw materials naturally follow. In addition, these bottles are resistant to abrasion and virtually indestructible. They withstand refrigeration without cracking, autoclaving without distortion and exposure to most chemicals. Significantly, the Owens-Illinois no-drip bottles are comparable in cost with many of today's packages.

Blow molding also permits the use of Grex resins that result in superior strain-free characteristics, often difficult to achieve by other techniques.

Sound interesting in terms of the products you make? Then you'll also be pleased with the surprisingly low mold costs, too. For the full story on this versatile plastics development call in the high density polyethylene experts. Grace has the production facilities, technical service and experience to help put your product in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION CLIFTON, NEW JERSEY

Blow molding with Grex offers fabricating economies and new product possibilities.

Blow molding is today's fastest growing fabricating technique—and no plastics lend themselves to blow molding better than high density polyethylene. This holds true whether the application is as straightforward as these Owens-Illinois bottles, or as complex as toy cars large enough to hold a child. Here are a few reasons behind the boom in blow molding with high density polyethylene:

Savings in mold and equipment costs. Because of the low pressures involved in fabricating Grex by this technique, lightweight molds can be made of easily toolable materials. Thus mold costs are ⅛ to ⅓ less than for any other fabricating method. Furthermore, blow molding is a simplified technique, often adaptable to existing injection molding and extrusion equipment.

Economies in resin requirements and cycle times. The physical properties of Grex (rigidity, heat distortion resistance, abrasion resistance) permit blow molding of thin wall sections. As a result, less resin is used per molded piece. Cycle time—even for large parts—is also reduced. Cycles in blow molding are limited only by the time it takes to cool a part. Thinner walls made possible by the characteristics of high density polyethylene speed cooling and cut cycles.

Ease of molding. Complex shapes with serious undercuts, often difficult to blow mold with other plastics, rarely present problems when a Grex blow molding resin is specified. In fact, fabricators find this technique permits use of resins having superior physical properties without sacrificing moldability. Also inherent in blow molding is the fact that costly assembly operations are held to a minimum. The large toy car, for example, is blown in a single piece.

Find out more. If you have an application for blow molding with high density polyethylene—or think you have—count on Grace for help. Write now to:

Technical Service Department
W. R. Grace & Co., Clifton, N.J.

DESIGN LITERATURE

Edison

MATTHEW JOSEPHSON. McGraw-Hill Publishing Co, 330 W 42nd St, New York 36. 9¼ x 6¼, 511 pp. $6.95.

Of all Thomas Edison's contributions, the one for which he is least known, and one that may well be his most important, was not a tangible device, but a method. Edison was the first man to create a research laboratory for the sole purpose of inventing and designing new products. He hired assistants to work on specific projects while he himself supervised the operation. His method of investigation was the forerunnner of the large research labs of today. Although his early inventions relating to telegraphy were conceived solely by Edison, the phonograph, electric light and motion picture projector were produced by hard-working technicians following "the wizard's" every direction.

Edison had the ability to surround himself with dedicated men, although a trusted companion once cheated him out of royalties. Strangely, Edison maintained a strong contempt for mathematicians. He kept several about his laboratory, but, only under outside pressure. One, Francis Upton, was nicknamed "Upton Culture" by Edison as a good-natured gibe at his education. To put Upton in his place, Edison brought out a pear-shaped glass bulb intended for lamp experiments at the Menlo Park Laboratory and gave it to Upton, asking him to calculate its cubic contents in centimeters.

"Upton drew the shape of the bulb exactly on paper, and got the equation of its lines, with which he was going to calculate its contents, when Edison again appeared and impatiently asked him for the results. The mathematician, after having worked an hour or so, said he was about halfway through and would need more time. 'Why,' said Edison, 'I would simply take that bulb, fill it with a liquid, and measure its volume directly.'" This practical approach to problems continued throughout Edison's career.

During the first World War, Edison was asked by the Navy Department to offset the German submarine threat. He realized that since most merchant-ship officers used visual points of reference such as lighthouses and familiar coastal points, all a submarine captain had to do was sit and wait by these landmarks. He asked the Navy for a map showing locations of all sinkings, thus indicating where the U-boats were most likely to be waiting.

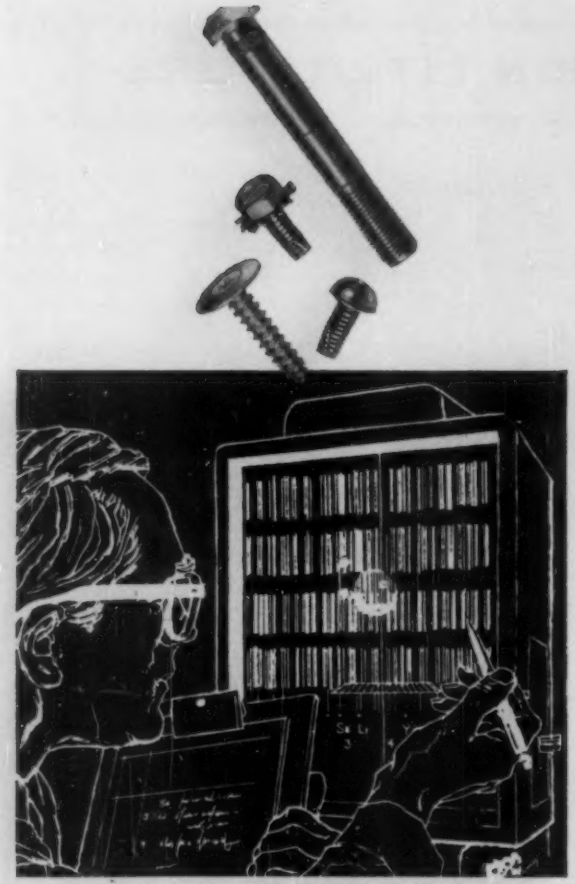
"Though the undersea attacks had been raging for more than a year, the US Navy had no such record." This investigation by Edison led to the Navy's establishment of a scientific research laboratory.

Edison was never a scientist. He was always an inventor, and like so many inventors, had little business sense. Often his backers reaped enormous profits from his ideas long after he had spent his earnings on new research.

Author Josephson takes the reader behind the legendary curtain of the Edisonian myth and chronicles some of the most exciting events of this country's industrial development — events like the bizarre "telegraph war" between Jay Gould and Western Union, the founding of General Electric, and Edison's bitter fight with George Westinghouse's company over alternating current. The glimpses of Gould, J. P. Morgan and other financiers make one believe that the struggling inventor today is a lot better off.

Unfortunately, Josephson does not place enough emphasis on Edison as a human being working with other human beings. The reason behind his rough but sentimental handling of employes, and co-workers would

(continued on page 73)



The high quality of

NATIONAL LOCK FASTENERS

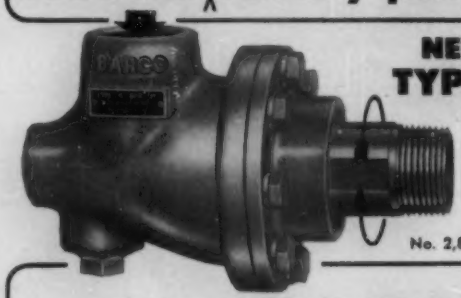
is more than skin deep

Quality wire is the basic ingredient for quality fasteners. That's why, at National Lock, quality control starts with elements of the raw wire. Here, a unique *spectograph* is used to make a complete qualitative analysis of the metal that goes into National Lock fasteners and cold-headed products. And, too, size, thread dimension, finish and other exacting customer specifications are checked with equal vigilance and thoroughness. National Lock fasteners are quality made inside and out to assure long-term, dependable performance.

STANDARD AND SPECIAL-PURPOSE FASTENERS FOR AMERICAN INDUSTRY SINCE 1909

NATIONAL LOCK COMPANY
FASTENER DIVISION, ROCKFORD, ILLINOIS

Need a *Better* rotary joint?



NEW TYPE C

Patent No. 2,836,439

-it's BARCO!

For countless applications, Barco's new Type C Rotary Joint will give you the best operating records you've ever had—*and for LESS COST!*

"CRACK-FREE" CHROME PLATED SLEEVE—A standard Barco feature. Minimizes corrosion, friction, wear. Stainless steel spring also standard.

RESISTS SEAL RING BREAKAGE—The spherical seal ring is under compression, not *tension*, loading. Self-adjusting for wear. Seal withstands shock loads and alternating hot and cold service.

WIDE SPACED BEARINGS—Two, instead of one . . . increased bearing area. No lubrication required. Lowest friction.

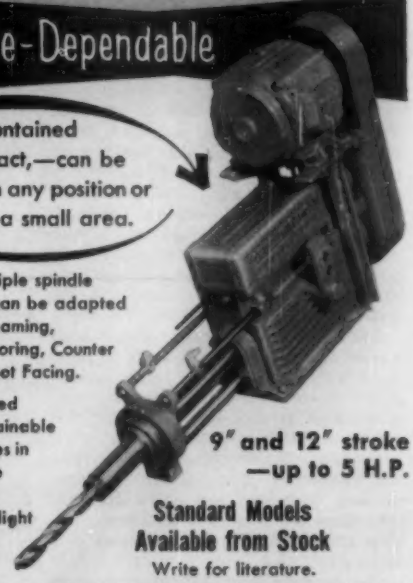
200 P. S. I. STEAM RATING—Heavy duty service at *no extra cost.* Eight sizes, ½" to 3". *Send for new Catalog 310 today.* **BARCO MANUFACTURING CO., 5278 Hough Street, Barrington, Illinois.**

CIRCLE 205 ON READER SERVICE CARD

DRILLUNIT *Solves* Drilling Problems

Flexible-Dependable

Self contained —Compact,—can be mounted in any position or angle, in a small area.



Single or Multiple spindle applications, can be adapted for Drilling, Reaming, Chamfering, Boring, Counter Boring and Spot Facing.

Stroke and feed variations obtainable without changes in the unit.—Step feed drilling possible with slight modification.

9" and 12" stroke —up to 5 H.P.

Standard Models Available from Stock

Write for literature.

DRILLUNIT, INC.
HYDRAULIC DRILL UNITS
3267 Wight Street • Detroit 7, Michigan

CIRCLE 72 ON READER SERVICE CARD

CIRCLE 206 ON READER SERVICE CARD

be interesting. His family life, the raising of his children, and his economic and political philosophy are touched upon too scantily. —BAL

Handbook of Electronic Control Circuits

JOHN MARKUS. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 8½ x 11¼, 272 pp. $8.50.

A compilation (from articles in *Electronics*) of over 250 circuits designed and used from 1956 to 1959. Circuits are grouped in chapters alphabetically according to function, and cross-indexed by name and category.

The Explosive Press as a Materials Research Tool

PB 151844. Office of Technical Services, US Dept of Commerce. 10½ x 8, 13 pp. 50¢.

This report ("The Explosive Press as a Research Tool in Material Behavior and Forming") reveals effective methods to compact powdered materials. High pressures point the way to several areas of immediate usefulness: compacting and bonding nonductile particles, for example, the prealloyed steel powders; also cold-weld bonding of dissimilar metals.

Graphite Technology

SAMUEL W BRADSTREET, Armour Research Foundation. (WADC Technical Report 58-503). Office of Technical Services, Dept of Commerce, Washington 25, DC. 11 x 8, 66 pp. $2.

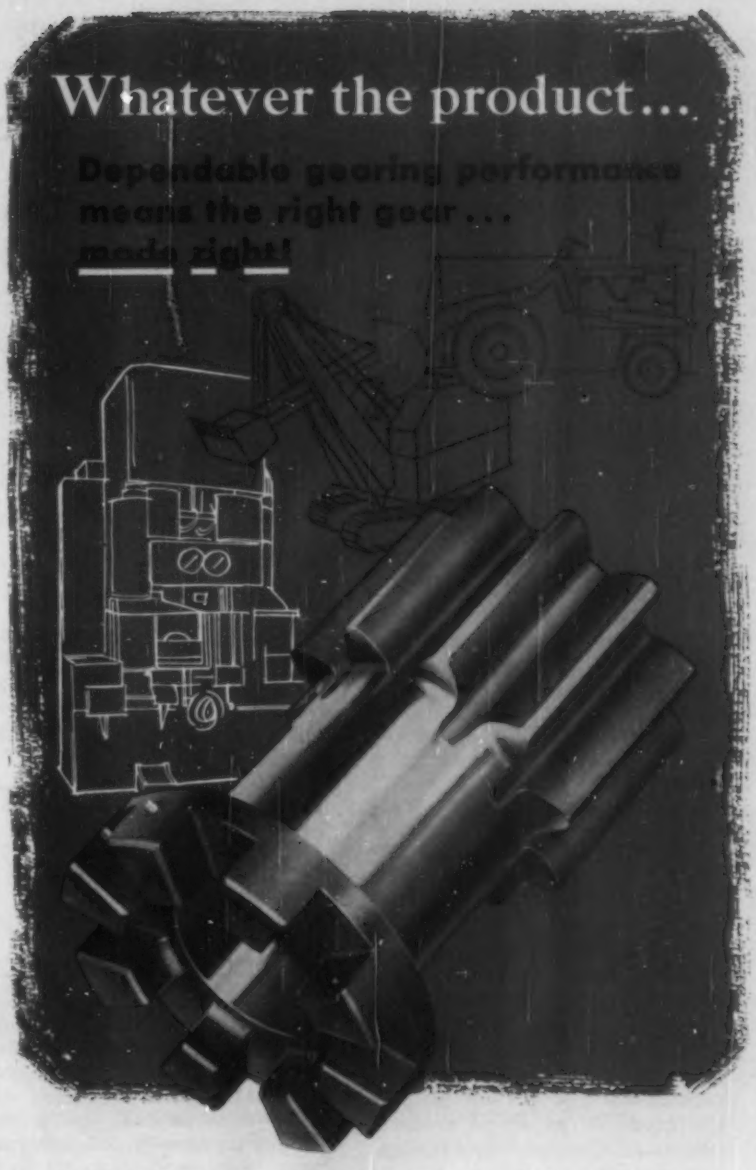
The Air Force project on graphite has resulted in several reports. This one, which summarizes principles that affect the structure and formation of graphite, investigates four carbon-base materials and a series of binders to try to find the best reproducibility for graphite.

Advanced Power Sources

PB 151748. Efficiency of Thermoelectric Generators, Borrego, Lynden, and Blair. 8 x 10½, 74 pp. $2.25.
PB 151430. Fundamental Investigation of Electrical Power Sources for Electric Thrust Devices. Helen Fife. 8 x 10½, 39 pp. $1.25.
PB 151726. Unconventional Electric Power Sources. Paul A McCollum. 8 x 10½, 101 pp. $2.50.
All available from Office of Technical Services, Dept of Commerce, Washington 25, DC.

Three new entries have been added to OTS's rapidly growing list of publications on advanced power sources—fuel cells, thermoelectric converters,

(continued on page 74)



Precision can be designed into any power transmission equipment. But precision performance results only when the gearing is made to the exact specifications for a particular application.

CINCINNATI Custom gears and gear boxes are precision made, precision inspected, GUARANTEED—*with delivery dates as promised!*

Send us your prints for quotation.

CINTI®

THE CINCINNATI GEAR CO.

Wooster Pike and Mariemont Ave. Cincinnati 27, Ohio
Custom Gear Makers Since 1907

GEARS, good gears only

and the like. Two cover fairly recent work. The third (PB 151726) was delayed 3 years in publication, but is still an extremely valuable reference work, giving much basic data on thermocouples, solar-energy converters, and the like.

PB 151748 is a highly technical, mathematical study of thermoelectric conversions; while PB 151430 is simply a bibliography.

Handbook of Chemistry

Compiled and edited by N A LANGE. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 5½ x 8, 1969 pp. $12.

The ninth edition of this always-valuable handbook contains much to interest the engineer as well as the chemist. It includes many tables on plastics, combustion constants of gases, properties of insulating materials, a glossary of ceramic terms, and a 41-page table of conversion factors which is, in itself, worth the price of admission.

Soldering Manual

Prepared by AWS Committee on Brazing and Soldering. American Welding Society, 33 W 39th St. New York 18, NY. 9 x 6, 170 pp.

The manual covers materials to be soldered, solder compositions and soldering processes. Its compilation of soldering methods, mostly manual, does not include the more recent wave-soldering and flux-waves techniques. The section devoted to joint design—about 10 pages—is informative but short. A good start, it brings the materials and processes into perspective because it provides an unbiased comparison. Contains little on design considerations.

ABSTRACTS FROM THE LITERATURE

Exposure Tests of Honeycomb Sandwich Structures

A summary of part of a three-year program during which a variety of sandwich construction and core materials were exposure-tested at two sites. One, at Kure Beach, North Carolina, was exposed to salt water atmosphere, direct rays of the sun, wind-driven sand, and several hurricanes. The second site, typical farm land at State College, Penna, had an environment of the normal weather of the northeastern United States, including exposure to sun, wind, rain, snow and ice.

"Effect of Natural Environment on Sandwich Structure Using AMS 3722 Paper Honeycomb Core," R. F. Zemer, Douglas Aircraft Co Inc; ASTM Paper No. 83. ASTM, 1916 Race St, Philadelphia 3.

Significance of Surface Finish

Dimensional values for surface condition are discussed, surface waviness is illustrated, technique of taper sectioning to reveal surface ridges is described, and the significance and geometry of surface roughness are analyzed.

"Significance of Surface Finish on Friction Wear and Lubrication," A. Sonntag, Alpha-Molykote Corp; presented at Seminar on Friction, Lubrication and Wear, Burgenstock, Switzerland, Sept 17-18. Available from Alpha-Molykote Corp, Stamford, Conn.

Lubricant Tests

This paper discusses the significance of the following tests: water, insolubles, sulfur, copper-strip corrosion, analine point, interfacial tension, dielectric strength, and turbine-oil emulsion.

"Significance of Specific Lubricant Tests," Texas Co; Lubrication Engineering, Oct '59, 135 E 42nd St, New York 17.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 78

ALUMINUM SCREW MACHINE STOCK—Manual, 120 pp. Three main sections discuss properties, specifications, estimating information and machining practice. Spiral-bound. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19.

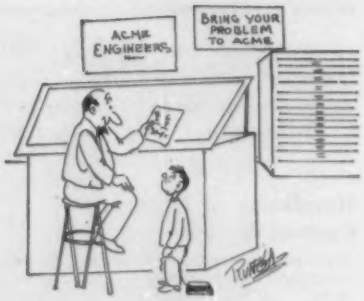
Circle 340 on Reader Service Card

HI-TEMP SELF-LOCKING NUTS—Catalog 5918, 80 pp. A guide to selection of nuts for use above 800 F. Includes resume of information on high-temperature terminology and phenomena such as stress rupture, creep and relaxation strength. Dept H, Elastic Stop Nut Corp, 2330 Vauxhall Rd, Union, NJ.

Circle 341 on Reader Service Card

ELECTRICAL SWITCHES AND TERMINALS—Catalog, 24 pp. Data on multicircuit pushbutton switches and multicircuit stack switches have been added to information on range-heater, motor-reversing, toggle and slide switches. With dimensional drawings, wiring diagrams, circuit sequences and electrical ratings. Ark-Les Switch Corp, 51 Water St, Watertown, Mass.

Circle 342 on Reader Service Card



"Well . . yes, son, that's what we advertise . . . but . . . ."

GEARBELT DRIVES—Catalog GB-201-A, 56 pp. To specifications on stock gear belts and gearbelt pulleys, catalog adds design and installation suggestions, performance data, dimensions and examples. Includes tables of practical stock drive combinations. Browning Mfg Co, Maysville, Ky.

Circle 343 on Reader Service Card

CONTROL VALVES—Digest catalog '59, 16 pp. Condensation of general catalog of air valves includes all standard models with envelope dimensions, model numbers, pipe sizes, JIC symbols and other specifications. Contains sketches, cutaway views, explanation of various types and typical pneumatic circuits and index. Ross Operating Valve Co, 120 E Golden Gate, Detroit 3.

Circle 344 on Reader Service Card

MECHANIZED HARD-FACING—Booklet, 24 pp. Discusses machines and materials for five types of hard-facings. Haynes Stellite Co, 420 Lexington Ave, New York 17.

Circle 345 on Reader Service Card

MECHANICAL DIFFERENTIALS—Booklet, 24 pp. Describes differentials, how they work, typical applications and design advantages. Pic Design Corp, 477 Atlantic Ave, East Rockaway, NY.

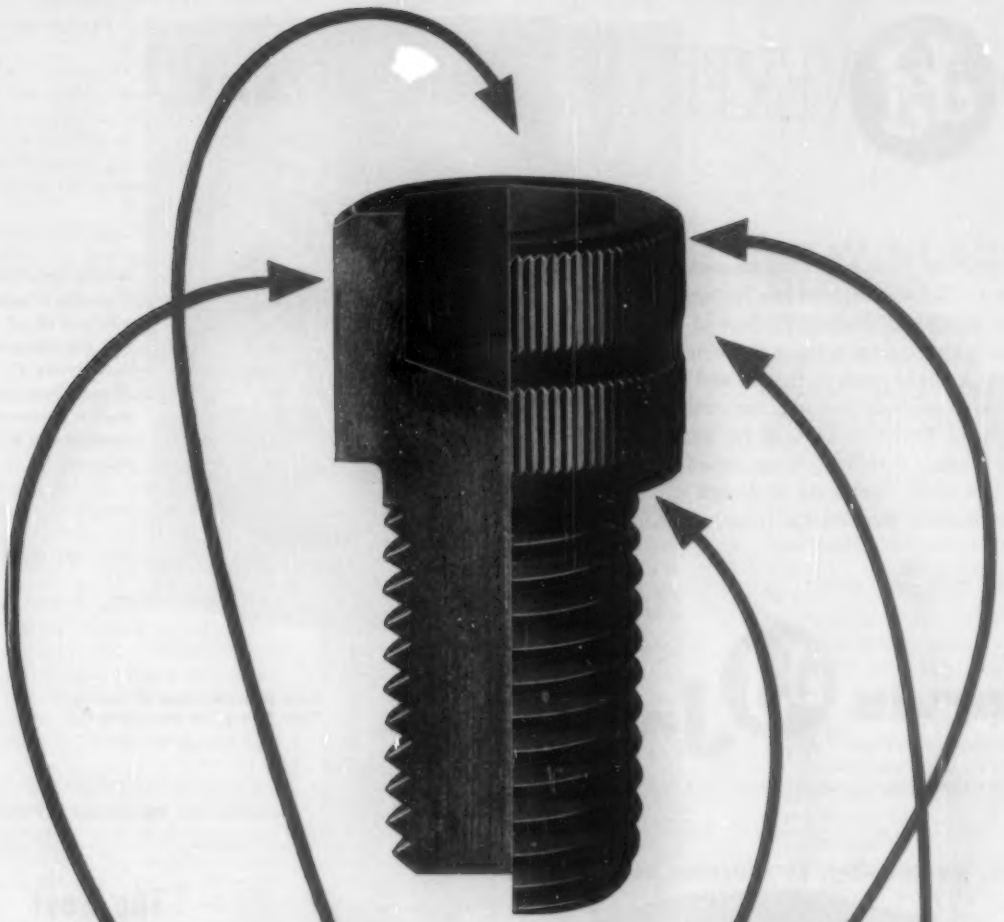
Circle 346 on Reader Service Card

PAINTING VS MOLDING IN COLOR—Brochure, 16 pp. Shows how painting of polystyrene and other thermoplastic parts often permits savings when compared with molding in color. Bee Chemical Co, Logo Div, 12933 S Stony Island Ave, Chicago 13.

Circle 347 on Reader Service Card

SECTIONAL TERMINAL BLOCKS—Catalog 76, 12 pp. Covers design, specifications and features of sectional termi-

(Continued on page 77)



THERE IS A DIFFERENCE IN SOCKET SCREWS

Look at this cut-away of a forged socket cap screw from H-K. Notice the smooth, flowing lines of the metal fibers that give greater strength to the screw . . . look at the clean sockets scientifically proportioned for maximum strength . . . observe the controlled forged fillet under the screw head. These are features no other socket cap screw can match.

You won't see other features just as important to your production line: special analysis alloy steel heat-treated to 39-42 Rockwell "C" hardness . . . threads formed to Unified Class 3A fit . . . a new and different forging method that produces the toughest socket screws made . . . an atmospherically controlled hardening process. And behind all these features, the now famous SAME-DAY SERVICE on all standard catalog items!

Look for the difference in H-K socket screws . . . see the difference at your production line!

HOLO-KROME SOCKET SCREWS

SOLD ONLY THROUGH AUTHORIZED HOLO-KROME DISTRIBUTORS

THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

CIRCLE 75 ON READER SERVICE CARD

NEW J&J VERTILOK

To provide greater locking strength, the J & J "Vertilok" side brake features a vertical cam action and a specially formed brake shoe which contacts the maximum tire tread area. A slight press of the toe and the wheel is securely locked . . . or completely released. Provision is made for adjustment of the braking action to compensate for wheel or tire wear. Simplicity of design and rugged construction assure long, trouble-free life.

Suitable for all 4" to 6" rubber wheels, with hard or soft tread; steel disc replaceable tread wheels, 4", 5" and 6" diameter; also medium casters with standard 4" x 4" top plate.

Sold Through Quality Dealers

Jarvis AND Jarvis, Inc.
PALMER, MASSACHUSETTS

Sales Representatives In Leading Cities Throughout the Country

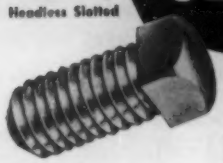
IN CANADA: Jarvis & Jarvis of Canada, 1744 William St., Montreal, Que.

CIRCLE 207 ON READER SERVICE CARD

design, purchasing, production men . . .

here's why you're right with MOORE SET SCREWS

Headless Slotted


Square Head

Socket Head

Design — there's a Moore Set Screw exactly right to meet your specs. On new developments or on hard-to-solve problems we have experienced men to supply the answers.

Purchasing — you can depend on us, without question, to meet your schedules. Your reputation is backed up by our reputation of 80 years of dependable service.

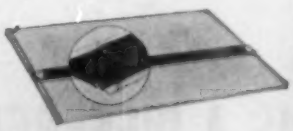
Production — our inspection guarantees conformity and uniformity. Your assembly lines run smoothly and quality control is simplified.

Moore Set Screws simplify design, purchasing, production. Send for detailed price catalog.

MOORE SET SCREWS

George W. Moore, Inc.
since 1890
92 Beaver St., Waltham 54, Mass.

MAYLINE



The Best Possible Combination

A Mayline Straightedge and a Mayline table. Mayline straightedges are made from moisture resistant black satin laminated phenolic plastic. Transparent edges are crystal clear. Available in 30" to 96" lengths. Straightedges completely described in Folder S-15.

These fine straightedges attached to the May-O-Matic table make an incomparable combination. The May-O-Matic top is adjustable for height positioning and required angle drawing position. It is available in 10 combinations. This amazing table explained in detail in Folder S-22.

MAYLINE CO., INC.
607 No. Commerce St.
Sheboygan, Wisconsin

MAYLINE MAYLINE MAYLINE

CIRCLE 76 ON READER SERVICE CARD

CIRCLE 208 ON READER SERVICE CARD

nal block, one-piece terminal blocks, solderless connectors for wire splicing and terminating and one-piece squeeze-type connectors for sheathed cable. Buchanan Electrical Products Corp, Hillside, NJ.

Circle 348 on Reader Service Card

AIRCRAFT STEELS–Booklet, 24 pp. Gives mechanical and physical properties of AM-350 and AM-355 steels at various temperatures. Also has sections on heat treating and fabrication. Allegheny Ludlum Steel Corp, Oliver Bldg, Pittsburgh 22.

Circle 349 on Reader Service Card

BRASS TUBE AND PIPE FITTINGS–Catalog 60-2, 16 pp. Describes line of tube and pipe fittings, with product illustrations and specifications. Brabant Brass Mfg. Co, 8925 Knox Ave, Detroit 11.

Circle 350 on Reader Service Card

SIZE 11 SERVO MOTORS–Catalog, 16 pp. Outlines electrical and mechanical specifications and shows individual schematics as well as torque-speed curves. Helipot Div, Beckman Instruments Inc, 2500 Fullerton Rd, Fullerton, Calif.

Circle 351 on Reader Service Card

ELECTRONIC WIRE AND CABLE–Catalog I-59, 16 pp. Lists 324 wire and cable items with application information and specifications. Also contains section on 70 tubing and sleeving items and pages on zipper tubing, lacing cord and tapes. Alpha Wire Corp, 200 Varick St, New York 14.

Circle 352 on Reader Service Card

TEST EQUIPMENT–1960 Catalog, 36 pp. Describes line of equipment to measure electrical characteristics of control synchros, torque synchros and computing resolvers. Covers theory of operation, operating procedure and specifications. Theta Instrument Corp, 520 Victor St, Saddle Brook, NJ.

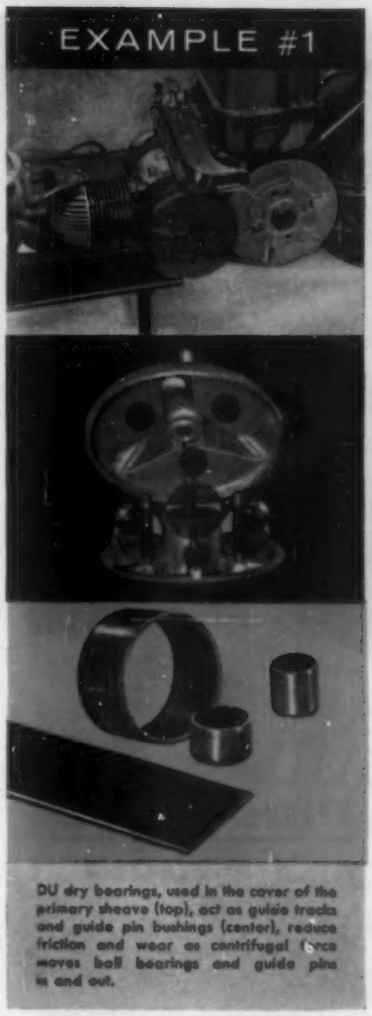
Circle 353 on Reader Service Card

RECORDING OSCILLOGRAPH–Bulletin 1536, 16 pp. Presents operation, features, specifications and interchangeable magazines and other accessories for oscillograph that records up to 50 channels of static or dynamic data. Electro Mechanical Instrument Div, Consolidated Electrodynamics Corp, 360 Sierra Madre Villa, Pasadena, Calif.

Circle 354 on Reader Service Card

SUPERALLOYS–Bulletins, 8 pp each. Cover performance of vacuum induction melted superalloys, description and chemical composition, physical constants, tables and charts of mechanical properties, isostress curves and information on heat

(continued on page 78)



DU dry bearings, used in the cover of the primary sheave (top), act as guide tracks and guide pin bushings (center), reduce friction and wear as centrifugal force moves ball bearings and guide pins in and out.

NEW GLACIER DU* DRY BEARINGS

greatly improve transmission design of Harley-Davidson "Topper"

Used at vital locations in the transmission assembly, DU dry bearings reduce friction and wear to the absolute minimum on the latest addition to Harley-Davidson's fine motor scooter line. DU dry bearings solve another problem, too—the accumulation of dirt and grime in the transmission lubrication. DU material requires no lubrication whatsoever, and will last many times longer than other dry bearings.

DU metal is an ideal bearing material. It withstands much higher velocities, runs much cooler at lower speeds than other unlubricated bearings . . . has a compressive strength of 51,000 p.s.i. DU metal is applied without the need for temperature-limiting adhesives . . . will withstand from −328°F to +536°F.

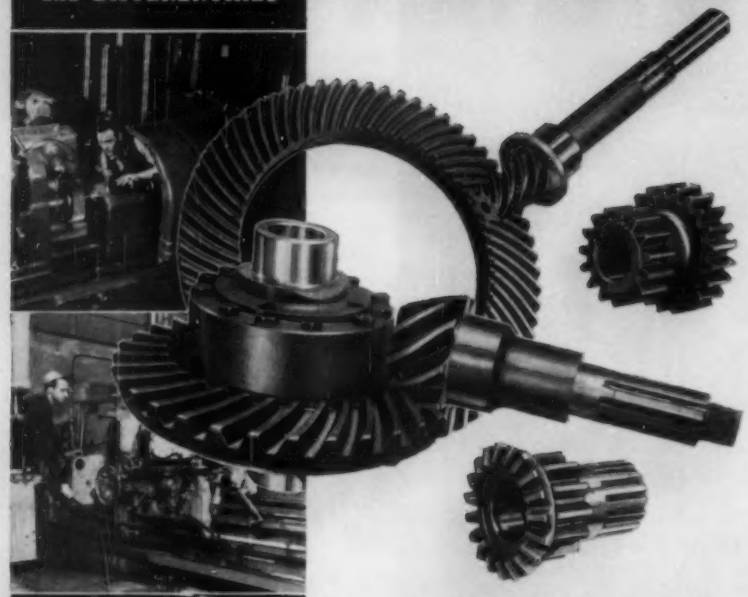
Apply DU material to appliances, automobiles, aircraft, farm and industrial machinery, office equipment. Standard bushings and thrust washers stocked for 3/8" to 2" shafts; strip available for special fabrication. Find out more from your bearing manufacturer, or write for engineering catalog DU-458. **Special Products Dept.,** United States Gasket Company, Plastics Division of The Garlock Packing Company, Camden 1, New Jersey.

GARLOCK

*Trademark, Glacier Metal Company Ltd.

GEARS
and DIFFERENTIALS

Your made to order by
FAIRFIELD



A Plus Value IN ANY PRODUCT!

Simple arithmetic explains why, TODAY, many of America's leading machine makers no longer undertake to solve the problems involved in production of gears, differentials, and specially designed gear parts. For them, FAIRFIELD IS THE ANSWER!

Every facility is available at Fairfield — latest, cost-cutting, ultra-modern metal-working and heat treating equipment, kept busy by volume production, *plus* expert engineering counsel. This makes for economy and efficiency that can benefit YOU.

Check with Fairfield NOW on your gear production schedules. As one of the nation's largest independent producers, Fairfield can usually give you quickest service available and handle any production requirement. *Become a Fairfield customer; it pays!* CALL OR WRITE.

FAIRFIELD
MANUFACTURING COMPANY, INC.
2305 South Concord Rd. Lafayette, Indiana
TELEPHONE: SHerwood 2-7353

Gears and Differentials for FINE GEARS *Made to Order for:*

TRACTORS • HEAVY DUTY TRUCKS • AGRICULTURAL MACHINERY • POWER SHOVELS AND CRANES
MINING MACHINES • ROAD GRADERS • BUSES • STREET SWEEPERS • INDUSTRIAL LIFT TRUCKS

treatment and finishing. Dept. 16, Kelsey-Hayes Co, New Hartford, NY.
Circle 355 on Reader Service Card

SIZE 8 SERVOMOTORS—Catalog, 16 pp. Electrical and mechanical specifications, outline drawings, schematics and torque speed curves are presented. Servomotors, Servomotor-rate generators, inertia-damp and adjustable velocity-damp servomotors in 115 v, 400 cps and 26 v, 400 cps versions are listed. Helipot Div, Beckman Instruments Inc, 2500 Fullerton Rd, Fullerton, Calif.
Circle 356 on Reader Service Card

MOLDED PACKINGS—Manual PY-959, 8 pp. Presents description of V-type molded packings consisting of series of three or more nested flat and V-cross-section rings. Discusses design considerations. Typical applications are shown. Greene, Tweed & Co, North Wales, Penna.
Circle 357 on Reader Service Card

BONDED METAL-TO-RUBBER SEALS—Brochure, 6 pp. Describes seals for quasi-static sealing where axial movement is utilized to effect seal to plane or conical surfaces. Offers applications, gives design information, shows various seal configurations and illustrates actual products using seals. Stillman Rubber Co, 5811 Marilyn Ave, Culver City, Calif.
Circle 358 on Reader Service Card

BLOWING URETHANE FOAMS—Brochure, 4 pp. Discusses recent developments in foam-making techniques. Isotron Dept, Pennsalt Chemicals Corp, 3 Penn Center, Philadelphia 2.
Circle 359 on Reader Service Card

LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

ELECTRONIC PARTS—1960 guide 85, 312 pp. Over 40,000 items are listed, including specifications, electronic symbols, schematic diagrams and useful formulas. Radio Shack, 730 Commonwealth Ave, Boston.

ELECTRICAL CONTROLS—Catalog, 32 pp. Descriptive and application information on direction and zero indicating contactor controls. Gives general information, electrical ratings, operational data, and specifications for each device included. Winterburn Mfg Co, Putnam, Conn.

ELECTRONIC CONNECTORS—Condensed catalog 60, 16 pp. Features standard lines of electronic connectors. Includes basic engineering application information on electronic connector types. Includes dimensions, mounting and dimensional drawings. H H Buggie Div, Burndy Corp, Toledo, Ohio.

Graders

Harvesters

Lift Trucks

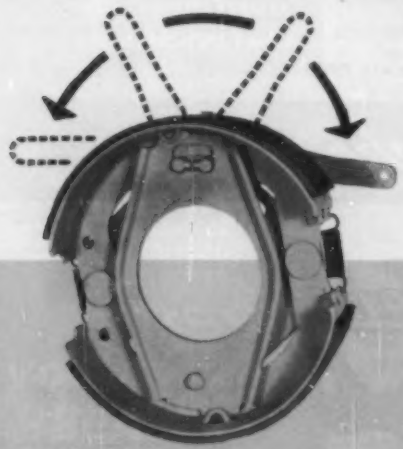
Trucks

ROCKWELL-STANDARD INTRODUCES NEW HEAVY-DUTY

HOLDMASTER

PARKING AND EMERGENCY

BRAKE!



Check These Holdmaster Advantages:

Designed for versatility. 360° lever positioning makes brake standardization now possible for various installations. Cam and lever construction minimizes input force losses. Unique cam design applies brake with either direction of lever movement.

Simplicity of parts. The Holdmaster has only eight different parts! Inventory requirements are reduced . . . simple external linkage adjustment means easier, faster maintenance.

Rugged, lightweight construction. More braking capacity per pound is achieved through new design advances.

Improved high-capacity performance! With Rockwell-Standard's new balanced design, both shoes of the new heavy-duty Holdmaster Brake do an equal amount of work. This assures greatly improved mechanical efficiency . . . extends lining life and reduces transmission rear bearing stress.

As a parking brake, the Holdmaster provides sufficient torque capacity to prevent wheels from rolling on any grade. Equal torque output is exerted in either direction of rotation with minimum input force and stroke.

For emergency stops, the Holdmaster divides the input force equally between both shoes. Stops are safe and controlled for maximum protection. Heavy-duty design provides braking power even after several "panic" stops.

For full details, write for Holdmaster brochure. Every Rockwell-Standard Brake is backed by nearly a half century of engineering and manufacturing experience.

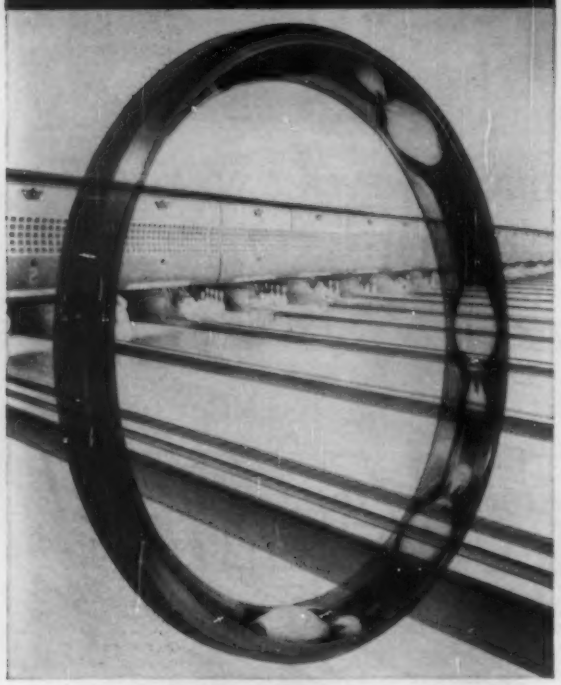
Another Product of...

ROCKWELL-STANDARD CORPORATION

Brake Division, Ashtabula, Ohio

CIRCLE 79 ON READER SERVICE CARD

Strikes, Spares and Spincraft



Most of the time, Spincraft's forty years of unmatched experience is spent in producing modern miracles for industry. Now, these same skills are making more leisure-time bowling fun for all America.

This giant circle is an important part of the almost-human pin setting machines made by Brunswick Balke Collender Company. Brunswick naturally turned to Spincraft, whose advanced metal spinning techniques produced this gleaming steel circle of efficiency.

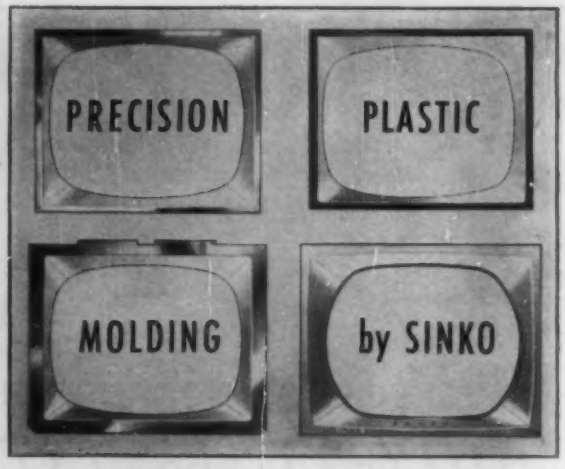
Whether it's for bowling, brewing, baking or breeders, Spincraft probably helped make it — better! Why not consult the metalforming leader — today?

Write for Spincraft's Notes for an Engineer's File, a series of bulletins to keep you abreast of the latest metalspinning advances at Spincraft — the world's largest metalspinning plant.

Spincraft
SKILL WILL DO IT ®
INCORPORATED

4137 West State Street, Milwaukee, Wisconsin

CIRCLE 80 ON READER SERVICE CARD



The TV Masks pictured are being mass produced by Sinko for one of the country's leading manufacturers. Our advanced method of molding them in multiple colors by an automatic spray and roller-coating process has resulted in increased efficiency and lower production costs.

We can cut *your* costs too . . . on Plastic Moldings!

WE MOLD ALL THERMOPLASTICS . . . from 2 to 175 oz.

Sinko MANUFACTURING and TOOL CO.
7310 W. WILSON AVE. • CHICAGO 31, ILL.

CIRCLE 209 ON READER SERVICE CARD

Weckesser CABLE CLAMPS

Black Nylon for high temperature and other severe service conditions.

of economical Ethyl-Cellulose for maximum service at minimum cost.

A STYLE AND SIZE FOR EVERY CABLE FASTENING REQUIREMENT

Weckesser Cable Clamps offer superior insulating properties, high strength, light weight . . . with *no* rust or corrosion.

Non-circular shapes also available. Immediate delivery from on-hand stocks.

▷ **WRITE TODAY FOR FREE SAMPLES AND PRICE SHEET**

Weckesser COMPANY
5705 Northwest Highway • Chicago 46, Ill.

CIRCLE 210 ON READER SERVICE CARD

Where actuating control and precision are paramount

—like in a giant supersonic wind tunnel

—or a precision machine tool

you'll find "BEAVERS"

BEAVER ball screws are specified by engineers around the world for control of motion. Compressing cold steel with hydraulic, 1500 psi force against immovable posts, and holding over to .000" in an 8 foot stroke—or extreme accurate 3 dimension positioning of numerically controlled machine tool are all "naturals" for this equipment.

Can your product be made more efficient with Beaver Ball Screws? Write for literature.

Beaver Precision Products INC.
CLAWSON, MICH.

REPRINTS

Selected articles in recent issues have been reprinted in convenient form for filing. As long as the supply lasts, readers in US and Canada can secure one copy of "P" numbered reprints, without charge, by using one of the Reader Service cards bound inside the back cover. Note that the card must be used within 60 days of publication date. If more than one copy is needed, see price list.

Cam Control Aids Planetary Gear
How a grooved cam can assist in obtaining a wide variety of output motion. Jan 4 Circle P 26

Reserve Strength in Metal Parts
More help on how far you dare exceed the yield strength. Dec 21 Circle P 25

Multi-variable Experiments Simplified
A tubular way to obtain maximum information from a minimum of tests. Dec 21 Circle P 24

Engineering-aptitude Tests
How good are they? What the tests are like—and some warnings to the unwary. Nov 30 Circle P 23

High-temperature Reinforced Plastics
How they behave under plasma jet oxy-acetylene torch and rocket-engine exhaust. Nov 23 Circle P 22

Mechanical Reliability
Mathematical tools as applicable to bearings, gears and rivets as they are to vacuum tubes or capacitors. Nov 16 Circle P 21

Reinforced-plastic Springs
Leaf springs from epoxy laminates can outperform steel. Nov 9 Circle P 20

Latest Trend in Bolt Threads
Root radius is getting larger—75% threads now; 55% threads a possibility. Nov 9 Circle P 19

18 Ways to Control Gear Backlash
This roundup includes latest devices for answering a chronic problem. Oct 26 Circle P 18

Pressure Drops in Pneumatic Systems
New method predicts losses when components are in series. Oct 26 Circle P 17

Yardsticks for Research Success
Equations and procedures used to gage the future of a product. Oct 19 Circle P 16

8 Steps to Better Engineering Writing
This eight-part report appeared in serial form from Sep 7 to Oct 26. Circle P 15

3 Steps to a Battery-powered Motor
Electric auto is example—how to choose

(continued on page 88)

BEAVER BALL SCREWS

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficient in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments, aircraft, machine tools, massive wind tunnel jacks, etc. For horizontal and vertical actions, indexing, inching and traversing. Consultation and engineering service available. Write for literature.

EXTREME ACCURATE POSITIONING • NO BACKLASH • RAPID START • ANY DIAMETER OR TRAVEL •

Beaver Precision Products INC.
CLAWSON, MICH.

D&B
When it's
SPRINGS
everyone's fancy
turns to
DUDEK & BOCK
WIRE FORMS—SPRINGS
and METAL STAMPINGS
D-&-B Parts deliver top performance at lower cost! Years of KNOW-HOW and quality control guarantee Wire Forms, Springs and Stampings that are easily assembled . . . withstand stress . . . and perform under the most trying conditions!
Write, Wire or Phone
DICKENS 2-1020
for ESTIMATES and
DELIVERY DATES
FREE
Brochure
DUDEK & BOCK SPRING MFG. CO.
4014 W. GRAND AVE., CHICAGO 51, ILL.
ADVANCE SPRING CORPORATION (a division of Dudek & Bock)
1749 W. Carroll • Chicago 12, Illinois

CIRCLE 212 ON READER SERVICE CARD

CLOSURES

- Metal or Plastic Caps or Plugs to protect threads, tubes, machined parts, reamers, cutters, tools.
- Protect against thread damage, dust, dirt, and moisture.
- For inside and outside application. All sizes. Immediate delivery.

METAL Caps to cover AN & SAE threads

PLASTIC tapered caps and plugs

METAL plugs for AN & SAE threads

PLASTIC tube cap for AN & SAE parts

Clover closures are made in metal and tough plastic polyethylene. They are made in caps, plugs and special shapes to fit parts tightly, offering completely sealed protection during manufacture, shipping and storage. Backed by years of closure experience. Write for low prices and complete information.

Send coupon today!

Gentlemen: Please send samples and prices of closures in Polyethylene ☐ Aluminum ☐

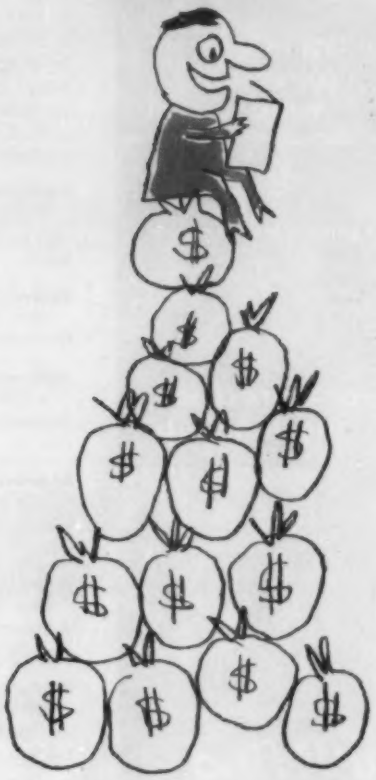
Name.....

Address.....

City.....

CLOVER INDUSTRIES, INC. 600 Young Street Tonawanda, N. Y.

Men who read more ...earn more!



Most of us recall at least one classmate who "never cracked a book", but somehow got by. But today, in business and industry, "just getting by" isn't good enough.

Men who get ahead read regularly and well . . . and particularly the McGraw-Hill specialized publication that is edited selfishly for them. Like this one for you.

Recently, research in another field showed that men who invested five hours a week in reading business magazines earned an average of 75 percent more than those men who spent only an hour in reading. It makes sense in your business, too . . . doesn't it?

Men who read more...earn more!

the best motor for the load. Oct 12
Circle P 14

Closer Look at Cast Iron
For predicting service performance, look at the miscrostructures. Oct. 12
Circle P 13

Planetary Drive Run by Rollers
Replacing gear drive cuts noise and vibration in fast planetary system. Oct 12
Circle P 12

Molding with Polyester Premixes
A different design approach is necessary with these reinforced plastics. Oct 12
Circle P 11

Ballbearing Tests
Combined reprint: test methods for torque, vibration and runout. Sep 14; devices to check preload and play. Sep 28
Circle P 10

13 Ways to Cut Drafting Costs
List of helpful modern methods, materials and equipment that save money. Sep 28
Circle P 8

More Engineering per Engineer
Review of new techniques designed to reduce the noncreative load on engineers. Sep 21
Circle P 6

QUANTITY PRICES
For single shipments of any one title to one address on order accompanied by remittance, quantity orders will be supplied at the following prices as long as the supply lasts.

Quantity	Price per Copy
5	$0.25
25	0.20
50	0.15
100	Write for quotation

Make checks payable to PRODUCT ENGINEERING, 330 West 42nd St., New York 36, NY.

SPECIAL REPORTS

In the event that you missed some of the Special Reports that appeared in PRODUCT ENGINEERING recently, here is a list of those still available. You may obtain any four for $1. Please enclose remittance with your order.

The NOR-Building Block for Logic Circuits
Simple multiple-input electrical relay can be combined with other devices to perform logic functions. R27

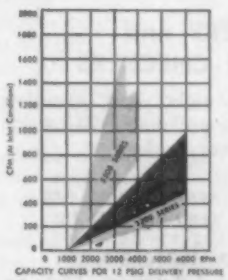
Design of External Shoe Brakes
New equations and coefficients provide a cook-book recipe. R26

Cast Epoxies Give Time-saving Models (12/21/59)
A discussion on how these plastics will give shortcut prototypes. R25

(continued on page 85)

new m-d engine mounted blowers

weigh only 625 lbs. Provide 400 SCFM continuous air flow



M-D answers the need for lightweight pneumatic units for vacuum or high pressure systems. Only 625 lbs. total weight of blower *and* engine. Dependable M-D units generate 15 PSIG of continuous air flow or up to 18 PSIG in surges. Ideal for mobile applications. M-D muffler packs mean quiet operation.

M-D blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 22 production models range from 50 to 4,000 CFM, pressures to 15 PSIG single, 70 PSIG multi-stage.

For full information write
M-D BLOWERS, INC., RACINE, WISCONSIN
A SUBSIDIARY OF MIEHLE-GOSS-DEXTER, INC.

STRESS ANALYST

ADVANCED ROCKET RESEARCH and DEVELOPMENT

HERCULES POWDER COMPANY
ALLEGANY BALLISTICS LABORATORY
CUMBERLAND, MARYLAND

Applicants should have graducte degree or equivalent experience in fields of (1) Pressure Vessel Analysis, (2) Composite Structure Analysis and (3) Plastic-Elastic Behavior of Materials. Familiarity with Shock and Vibration Analysis helpful but not a requirement.

The work is varied and challenging for persons having the ability to generate and direct testing programs and will lead to increased supervisory responsibilities.

Submit resume with full particulars to-

MR. W. D. LINKENHOKER
HERCULES POWDER COMPANY
ALLEGANY BALLISTICS LABORATORY
BOX 210 CUMBERLAND, MARYLAND

---

baroswitch development engineer

Graduate mechanical engineer with 5 to 7 years' product design experience in the field of small mechanical or electro-mechanical devices. Minimum 3 years' experience in field of barometric switches. Will independently direct a baroswitch development program.

Please write F. W. Miller, Dept. 226, Honeywell, 2753 Fourth Ave. So., Mpls.

Honeywell
First in Controls

PROJECT ENGINEER

If you have experience in machine design and know the field of paper converting, you can turn your ideas into results at Waldron. You will take charge of interesting, challenging design projects and supervise competent personnel. Your responsibility will extend from establishing or interpreting the initial specifications to successful operation of the equipment in the field.

Please write describing experience, education, salary requirements to A. W. Pompar, Director of Engineering

WALDRON-HARTIG
DIVISION OF MIDLAND ROSS CORP.
P. O. Box 791 New Brunswick, N. J.

DEVELOPMENT ENGINEERING GROUP

A dynamic, rapidly expanding manufacturer in the field of xerography (physical photography based on solid-state and electrostatic phenomena) has outstanding growth opportunities for:

SECTION LEADER

M.E., 8 to 12 years' experience in design and development of complex electro-mechanical devices. Knowledge of military design requirements essential.

PROJECT and SENIOR PROJECT ENGINEERS

M.E., 6 to 12 years' experience in complex electro-mechanical devices. Knowledge of military specifications and requirements desirable.

ASSOCIATE ENGINEERS

M.E. or E.E., 1 to 4 years' product experience in electro-mechanical machines and equipment.

PRODUCT ENGINEERS

M.E., E.E., or I.E., 3 to 8 years' experience in electro-mechanical product design for manufacturing.

CHECKERS and SENIOR CHECKERS

Six to eight years' experience in electro-mechanical devices—at least one year in checking.

- ***Kindly send resume and salary requirements to:***

FRED A. WETERRINGS
Industrial Relations Division

HALOID XEROX INC.
P. O. Box 1540,
Rochester 3, New York

HALOID XEROX®

MECHANICAL
ELECTROMECHANICAL
HYDROMECHANICAL

design engineers

Hamilton Standard

Division of UNITED AIRCRAFT CORP.

has immediate openings with excellent advancement potential

You should have an ME, EE or AE degree plus experience in design of high pressure rotating equipment for aircraft engine control and environmental control systems. Will be asked to conceive and plan realistic design programs.

These openings have been created by a swift-moving product diversification program involving equipment for jet aircraft, rockets, and missiles. And this steady expansion into new areas offers unmatched security, professional challenge and advancement prospects.

Enjoy pleasant country, suburban or city living in Connecticut . . . an opportunity for tuition-paid post graduate study . . . generous relocation allowance.

•

Reply to Mr. Richard Fuller, Dept. 30

Hamilton Standard

A Division of UNITED AIRCRAFT CORP.
138 Bradley Field Rd., Windsor Locks, Conn.

EMPLOYMENT OPPORTUNITIES

DISPLAYED RATE

The advertising rate is $37.00, effective January, 1960 per inch for all advertising appearing on other than contract basis. Frequency rates quoted on request.

UNDISPLAYED RATE

$2.10 per line, minimum 3 lines. Position Wanted ads in this style ½ the above rate. To figure advanced payment count 5 average words to a line.

ENGINEER—Mechanical Power Transmission

We can offer an excellent opportunity for advancement to an outstanding Mechanical Engineer in design and development of flexible couplings and other mechanical power transmission equipment. We want a man who has initiative, ideas and experience in this field.

Please write listing experience, education and present salary to:

A. W. Pompar, Director of Engineering
WALDRON-HARTIG
Division of Midland-Ross Corp.
P.O. Box 791 New Brunswick, N. J.

Booming manufacturer of compressed air products needs

ENGINEER with managerial abilities and product design experience

Live in Colorado; New building, pleasant working conditions, fringe benefits—Salary open.
Write, resume of experience, salary requirements
Employment Dept., 800 W. 9th Ave., Denver 4, Colorado

To EMPLOYERS Who Advertise for MEN:

Frequently, when there are many applicants for a position, only the most promising letters are acknowledged. The other applicants never know whether their letters reached a prospective employer or not. These men often become discouraged, will not respond to future advertisements and even question their bona fide character.

Every Advertisement Printed in the Employment Section Is Duly Authorized.

You can help keep our readers interested and get better returns to your advertising in this section if you acknowledge each reply—in plain envelopes, if you wish.

Classified Advertising Division

McGRAW-HILL PUBLISHING CO., INC.

"Put Yourself in his place."

CURRENT REPRINTS.....continued

Selecting the Right Electrical Connection (12/7/59)
This special report compares all types—permanent and separate. R24

Structural Models (10/26/59)
In three parts: I—Theory of Similitude; II—Building the Better Model; III—The Model at Work. R23

Engineering Organization in Transition (5/11/59)
Study of some 50 organizations showing their latest setups, reasons for changes, budgeting, titles and ratios of engineers to total company employment. R22

The Engineer's Bookshelf (Now—3/30/59)
Detailed bibliography of technical books for the design engineer. Handbooks, texts (22 subject classifications), bibliographies, library references and periodicals. R21

Designing with Swivel Joints
How to choose between swivels and flexible hose; how to select the proper type or combination of joints, and calculate pressure loss. R20

Modernize Now
Why and how to modernize the engineering design function: how to calculate R & D investment, costs and manpower needs; engineering laboratory, drafting equipment; company library; model shop. R19

Sandwich Panel Materials
Selection guide for core materials, facings and adhesives—presented in tabular form. Core materials include vegetable, mineral and plastic in solid, honeycomb and foam. Data on facings, cover metal, wood and plastic. Adhesives table lists properties for the 14 most widely used. R18

The Engineer Comes Into His Own (3/31/58)
Summary of current thinking on what makes him tick; his growing ties with other sciences; his responsibilities as individual, citizen and human being . . . and what tomorrow holds for him. R17

Pre-painted Steel (12/9/57)
Metal preparation, how to choose a paint, paints available. R14

Lubricating With Air (11/25/57)
How to design hydrodynamic gas bearings including latest research information on gas bearings developed through a cooperative program sponsored by 11 government agencies. R13

Color and Textures for Aluminum (9/30/57)
How texture and color are added to aluminum surfaces; texture and surface design, metallurgical finishes, application of color. R12

Strataflo
ALL-POSITION CHECK VALVE

Sensitive Rugged

For steam, hot or cold water, oil, gas and compounds.

Designed for rugged service. Also available with Buna rubber poppet for use with air or cold water. Sensitive in operation. Work in any position. Made in seven sizes, 200 lbs. pressure. We will design special Check Valves; tell us your needs. Write for Bulletin 201 and prices

Order from your jobber.

STRATAFLO PRODUCTS, INC.
FORT WAYNE, INDIANA

CIRCLE 85 ON READER SERVICE CARD

DO YOUR COPIES OF

Product Engineering

ARRIVE ON TIME

If not, perhaps it is because there is an error in the address. Look at the address label now.

Check for:
Spelling
Street Number
Street Name
and in particular
Zone Number

Incorrect zoning or no zone number where one should be can slow up delivery by hours or days. Check now and let us know of any corrections.

Product Engineering
330 West 42nd St.
New York 36, N. Y.

INDEX OF PRODUCTS
ADVERTISED IN THIS ISSUE

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD

A

Actuators
  Mechanical 81

B

Balls 18
Bearing Materials 77
Bearings
  Ball 18
  Miniature 66
  Needle 18, 29
  Roller ..... 4th Cover, 18, 29
  Self-Lubricating 77
  Sleeve 66
Belts, V 60
Blowers 83
Books 88
Brakes
  Hydraulic 79
  Mechanical 79
  Pneumatic 79
Brazing
  Alloys 28
Bushings 77

C

Cam Followers 29
Casters 76
Ceramics 67
Chains
  Conveyor 11, 64
  Roller 11, 64
Clamps 80
Closures 82
Clutches
  Mechanical 21

D

Differentials 78
Drafting
  Supplies 76

E

Electrochemical Finishes & Treatments 19
Extrusions
  Metallic 5

F

Fastening Methods 20, 34, 72
Floats 65
Friction Materials 6
Furniture, Engrg. Dept. 76

G

Gaskets 23, 32
Gears 22, 73, 78

J

Joints
  Swing & Swivel 72

M

Metal Forming 28
Moldings
  Plastics (see Plastic Parts)
  Powdered Metal (see Powdered Metal Parts)
Motor Starters 33
Motors, A-C
  Fractional ..... 3rd Cover, 31, 33
  Integral 12, 31, 33
  Sub-Fractional ..... 3rd Cover
Motors, D-C
  Fractional ..... 3rd Cover, 31, 33
  Integral 12, 31, 33
  Sub-Fractional ..... 3rd Cover
Motors, Hydraulic 72

N

Nickel Alloys 2
Nuts 20, 34, 80

P

Photographic Equipment
  Film 26-27
Plastic Parts 80
Plastics 70-71, 80
Powdered Metal Parts 6, 66
Power Packs
  Hydraulic 69
Power Take-Offs 21
Pumps
  Liquid 19, 69

R

Relays 17
Reproduction Equipment 26-27
Resins 70-71
Revolving Joints (see Joints, Swing & Swivel)

S

Screws 75, 76, 80
Seals ..... 2nd Cover, 23, 32
Silver Alloys 28
Specialty Fasteners (Pipe Hangers, Special Cold Headed Parts, etc.) 34, 72
Speed Increasers & Reducers 21
Spinning 80
Springs 82
Sprockets 11, 64
Stampings 82
Switches 10

T

Timers 14
Tubing
  Seamless 5
  Welded 5

V

Valves
  Air 30
  Hydraulic 30, 69, 85
  Solenoid 30

W

Washers 77
Wire Cloth 58
Wire Forming 82

INDEX TO ADVERTISERS

This index published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

A

Acme Chain Corp. 64
Armstrong Cork Co. 23

B

Babcock & Wilcox Co., Tubular Products Div. 5
Barco Mfg. Co. 72
Barksdale Valves 30
Beaver Precision Products, Inc. 81
Brown & Sharpe Mfg. Co., Double A Products Co., Subs. 69

C

Cambridge Wire Cloth Co. 58
Chicago Rawhide Mfg. Co. ..... 2nd Cover
Cincinnati Gear Co. 73
Clover Industries, Inc. 82

D

Delco Moraine Div., General Motors Corp. 6
Double A Products Co., Subs., Brown & Sharpe Mfg. Co. 69
Drillunit, Inc. 72
Dudek & Bock Spring Mfg. Co. 82

F

Fairfield Mfg. Co. 78

G

Garlock Packing Co. 77
Grace & Co., W. R., Polymer Chemicals Div. 70-71

H

Holo-Krome Screw Corp. 75

I

Industrial Tectonics, Inc. 18
Industrial Timer Corp. 14
International Nickel Co., Inc. 2

J

Jarvis & Jarvis, Inc. 76

L

Line Electric Co., Affiliate, Industrial Timer Corp. 17
Link-Belt Co. 11
Lucas Milhaupt Engineering Co. 28

M

McGill Mfg. Co., Inc. 29
McGraw-Hill Book Co., Inc. 88
M-D Blowers, Inc., Subs. of Miehle-Goss-Dexter, Inc. 83
Mayline Co., Inc. 76
Micro Switch, a Div. of Minneapolis-Honeywell Regulator Co. 10
Minnesota Mining & Mfg. Co. 26-27
Moore, Inc., George W. 76

N

National Lock Co. 72
Nicholson & Co., W. H. 65
Northfield Precision Instrument Corp. 66
Norton Co., Refractories Div. 67

P

Palnut Co., Div., United-Carr Fastener Corp. 20
Perkins Machine & Gear Co. 22

R

Reuland Electric Co. 12
Robbins & Myers, Inc. 31
Rockford Clutch Div., Borg-Warner Corp. 21
Rockwell-Standard Corp., Brake Div. .. 79

S

Sinko Mfg. & Tool Co. 80
Spincraft, Inc. 80
Strataflo Products, Inc. 85

T

Technic, Inc. 19
Timken Roller Bearing Co. ..... 4th Cover
Tinnerman Products, Inc. 34

U

U. S. Rubber Co., Mechanical Goods Div. 60
Universal Electric Co. ..... 3rd Cover

V

Vellumoid Co. 32
Viking Pump Co. 19

W

Wagner Electric Corp. 33
Weckesser Co. 80

PHILIP G WEATHERBY *advertising sales manager*
P F PRITCHARD *manager, market research*
ROBERT C MATTOON *circulation manager*
RUSSELL T DOUGLAS *business manager*

ADVERTISING SALES STAFF

ATLANTA 3 . . . W. O. Crank, 1301 Rhodes-Haverty Bldg, Jackson 3-6951
BOSTON 16 . . . M. A. Williamson, Jr., 350 Park Square Bldg, Hubbard 2-7160
CHICAGO 11 . . . Mid-Western Adv Sales Manager, A. E. Meanor; R. W. Bruley, L. Anderson, 520 N Michigan Ave, Mohawk 4-5800
CLEVELAND 13 . . . A. F. Tischer, 1164 Illuminating Bldg, 55 Public Sq, Superior 1-7000
DALLAS 1 . . . R. T. Wood, 901 Vaughn Bldg, 1712 Commerce St, Riverside 7-5117
DENVER 2 . . . John W. Patten, 1740 Broadway, Mile High Center, Alpine 5-2981
DETROIT 26 . . . P. B. Robinson, 856 Penobscot Bldg, Woodward 2-1793
LOS ANGELES 17 . . . Robert Obenour, 1125 West 6th St, Madison 6-9351
NEW YORK 36 . . . B. K. Adams, F. J. McKinley, 500 Fifth Ave, Oxford 5-5959
PHILADELPHIA 3 . . . D. G. Jones, K. S. Willadson, 6 Penn Center Plaza, Locust 8-4330
PITTSBURGH 22 . . . C. F. Leveroni, 1111 Oliver Bldg, Express 1-1314
ST LOUIS 8 . . . R. W. Bruley, 3615 Olive St, Continental Bldg, Jefferson 5-4867
SAN FRANCISCO 4 . . . W. C. Woolston, 68 Post St, Douglas 2-4600

SUBSCRIPTIONS. Send subscription correspondence and change of address to Fulfillment Manager, PRODUCT ENGINEERING, 330 W 42nd St, New York 36, NY. Subscribers should notify Fulfillment Manager promptly of any change of address including postal zone number, if any. If possible, enclose an address label from a recent issue of the magazine. Since copies are addressed one to two issues in advance, please allow one month for change of address to become effective. Subscriptions are solicited only from executives, engineers and consultants engaged in the design of machinery and other engineered products. Position and company connection must be indicated on subscription orders.

McGraw-Hill Publishing Co. Inc, publisher, Donald C. McGraw, president; Joseph A. Gerardi, executive vice-president; L. Keith Goodrich, vice-president and treasurer; John J. Cooke, secretary. Officers of the Publication Division: Nelson L. Bond, president; Harry L. Waddell, senior vice-president; John R. Callaham, vice-president and editorial director; Joseph H. Allen, vice-president and director of advertising sales; A. R. Venezian, vice-president and circulation coordinator.

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES 84-85

Index to Advertisers appears on P. 87
Products Index appears on P. 86

SPECIAL INTRODUCTORY OFFER

to new members of the

MECHANICAL ENGINEERS' BOOK CLUB

Publisher's Price, $8.50
Club Price, $7.25

Mechanics of Machinery by C. W. Ham, E. J. Crane, and W. L. Rogers. Fourth Edition. Methods, data, and theory in all major areas of mechanics.

Publisher's Price, $8.25
Club Price, $6.95

Formulas for Stress and Strain by R. J. Roark. Third Edition. Ready manual of formulas and facts pertaining to strength of materials.

Publisher's Price, $8.50
Club Price, $7.25

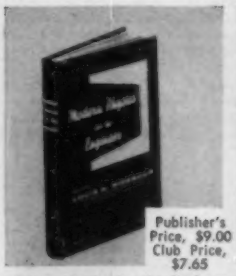
Mechanism by J. S. Beggs. Practical methods of analyzing complex mechanisms and solving mechanical design problems.

Publisher's Price, $9.50
Club Price, $8.10

Applied Mathematics for Engineers and Physicists by L. A. Pipes. Second Edition. Practical help in solving physics and engineering problems.

Publisher's Price, $8.00
Club Price, $6.80

Epoxy Resins by H. Lee and K. Neville. Complete guide to the field covering chemical preparation and industrial applications.

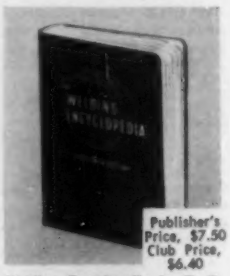


Publisher's Price, $9.00
Club Price, $7.65

Modern Physics for the Engineer by L. N. Ridenour. Examines physical science on which modern engineering is based.

Publisher's Price, $7.00
Club Price, $5.95

Professional Engineer's Examination Questions and Answers by W. S. LaLonde. Quick, easy help for passing license examinations.



Publisher's Price, $7.50
Club Price, $6.40

Welding Encyclopedia by T. B. Jefferson. 13th Edition. Complete details on over 2000 welding subjects.

HANDBOOK of FASTENING and JOINING of METAL PARTS

By V. H. Laughner and A. D. Hargan (Publisher's Price, $15.00). For every metal fastening and joining problem, here is your idea book for instant help. Gives scores of tips to speed your designs into low-cost production.

How many of the books shown here do you wish you had immediately at hand?

Select one of the 8 books listed above AS A GIFT —or, if you prefer, choose the *Handbook of Fastening and Joining of Metal Parts* for ONLY $1.00— your introduction to membership in the *Mechanical Engineers' Book Club*.

If you're missing out on important technical literature—if today's high cost of reading curbs the growth of your library—here's the solution to your problem. *The Mechanical Engineers' Book Club was organized for you*, to provide an economical technical reading program that cannot fail to be of value to you.

All books are chosen by qualified editors and consultants. Their thoroughgoing understanding of the standards and values of the literature in your field guarantees the authoritativeness of the selections.

How the Club operates. Every second month you receive free of charge *The Mechanical Engineers' Book Club Bulletin*. This gives complete advance notice of the next main selection, as well as a number of alternate selections. If you want the main selection you do nothing; the book will be mailed to you. If you want an alternate selection . . . or if you want no book at all for that two-month period . . . notify the Club by returning the form in the envelope enclosed with your *Bulletin*.

We ask you to agree only to the purchase of three books in a year. Certainly out of the large number of books in your field offered in any twelve months there will be at least three you would buy anyway. By joining the Club you save yourself the bother of searching and shopping, and save in cost about 15 per cent from publishers' prices.

Send no money now. Just check any two books you want—one FREE (or the *Handbook* for only $1.00) and one as your first selection—in the coupon below. Take advantage of this offer now, and get two books for less than the regular price of one.

THIS COUPON IS WORTH UP TO $14.00

The Mechanical Engineers' Book Club PE-1-4
330 West 42nd Street, New York 36, N. Y., P.O. Box 97

Please enroll me as a member of the Mechanical Engineers' Book Club. I am to receive my FREE book, or the *Handbook* for only $1.00, along with my first selection—as I have indicated at the right. You will bill me for my first selection only at the special club price, plus a few additional cents for delivery. (The Club assumes this charge on prepaid orders.) Forthcoming selections will be described to me in advance. I need take only 3 selections or alternates in 12 months of membership.

PLEASE PRINT

Name .....

Address .....

City .....Zone.....State.....

Company .....

NO RISK GUARANTEE If not completely satisfied, you may return your first shipment within 10 days and your membership will be canceled.

☐ Check here if you want the *Handbook of Fastening and Joining of Metal Parts* for only $1.00, and check one (1) book listed below as your first Club selection.

— OR —

Check two books below. We will send the higher priced book as your FREE book.

—Mechanics of Machinery, $7.25
—Formulas for Stress & Strain, $6.95
—Mechanism, $7.25
—Applied Mathematics for Engineers & Physicists, $8.10
—Epoxy Resins, $6.80
—Modern Physics for the Engineer, $7.65
—Professional Engineer's Examination Questions and Answers, $5.95
—Welding Encyclopedia, $6.40

PE-1-4

Get Complete Information Promptly... Use These Convenient, Time-Saving Cards

To be fully informed of all the significant new developments in your field is a vital and never-ending task. We make this big job easier for you. By just using one of the attached postcards you can secure:

- ...reprints of articles you'll use most often for a concise, ready source of material
- ...complete data on components and materials of utmost importance to you
- ...new catalogs and bulletins (those summarized in Product Engineering have first been carefully screened by our large staff of engineer-editors)
- ...more details on advertised products
- ...subscription to PRODUCT ENGINEERING

Please turn the page and make your selections. We do the rest.

HOW TO USE CARDS

Every Advertisement, New Product and Bulletin is numbered. For more information, circle KEY number that corresponds to number at the bottom of Advertisement, New Product or Bulletin.

For single copy of Free reprints offered, circle P number that corresponds to reprint requesting (listing inside).

To start your subscription to PRODUCT ENGINEERING, fill in card marked "subscription".

CAUTION: Do not forget to print your name, title, address and company name before mailing.

Issue of January 4, 1960
Product Engineering
Card expires March 4, 1960

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

Issue of January 4, 1960
Product Engineering
Card expires March 4, 1960

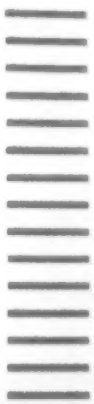
FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

SUBSCRIPTION



USE THESE CONVENIENT CARDS FOR A

EDITORIAL REPRINTS AVAILABLE

(Single reprint free — quantity prices and descriptions on page 81)

P6—MORE ENGINEERING PER ENGINEER—9/21/59

P8—13 WAYS TO CUT DRAFTING COSTS—9/28/59

P10—BALLBEARING TESTS—9/28/59

P11—MOLDING WITH POLYESTER PREMIXES—10/12/59

P12—PLANETARY DRIVE RUN BY ROLLERS—10/12/59

P13—CLOSER LOOK AT CAST IRON—10/12/59

P14—3 STEPS TO A BATTERY-POWERED MOTOR—10/12/59

P15—8 STEPS TO BETTER ENGINEERING WRITING—9/7—10/26

P16—YARDSTICKS FOR RESEARCH SUCCESS—10/19

P17—18 WAYS TO CONTROL GEAR BACKLASH—10/26

P18—PRESSURE LOSSES IN PNEUMATIC SYSTEMS—10/26

P19—LATEST TREND IN BOLT THREADS—11/9

P20—REINFORCED PLASTIC SPRINGS—11/9

P21—MECHANICAL RELIABILITY—11/16

P22—HIGH-TEMPERATURE REINFORCED PLASTICS—11/23

P23—ENGINEERING APTITUDE TESTS—11/30

P24—MULTI-VARIABLE EXPERIMENTS SIMPLIFIED—12/21

P25—RESERVE STRENGTH IN METAL PARTS—12/21

P26—CAM CONTROL AIDS PLANETARY GEAR—1/4/60

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P6 P8 P10 P11 P12 P13 P14 P15 P16 P17
P18 P19 P20 P21 P22 P23 P24 P25 P26

*MULTIPLE PRODUCT ADS

Key No.	Specific Product

Please print or type

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

DON'T BE LOW MAN ON THE ROUTING LIST!

Have your own personal subscription to PRODUCT ENGINEERING sent each week to your office or home. You are then sure that you won't miss a single weekly issue. Further, each year of your subscription you will have your copy of the annual, thick Design Digest issue to read and refer to for years to come.

☐ 1 year—$5 U.S. only* ☐ 2 years—$8

*Canada
1 year—$7
2 years—$12

☐ Payment enclosed

☐ Bill me

Name ..... Title .....

Home ☐ .....

Address Office ☐ ..... Dept.....

City ..... Zone ..... State .....

Company Name ..... Product Mfgd.....

NEW CATALOGS AND BULLETINS

GENERAL ENGINEERING

353—Test Equipment, 36 pp, Theta Instrument Corp.

354—Recording Oscillograph, 16 pp, Electro Mechanical Instrument Div., Consolidated Electrodynamics Corp.

METALS AND ALLOYS

340—Aluminum Screw Machine Stock, 120 pp, Aluminum Co. of America

349—Aircraft Steels, 24 pp, Allegheny Ludlum Steel Corp.

355—Superalloys, 16 pp, Metals Div., Kelsey-Hayes Co.

NON-METALLIC MATERIALS, FINISHES

347—Painting vs Molding in Color, 16 pp, Logo Div., Bee Chemical Co.

FABRICATION PROCESSES AND PRODUCTION

345—Mechanized Hard-Facing, 24 pp, Haynes Stellite Co.

359—Blowing Urethane Foams, 4 pp, Isotron Dept., Pennsalt Chemicals Corp.

POWER TRANSMISSION

343—Gearbelt Drives, 56 pp, Browning Mfg. Co.

MECHANICAL PARTS

346—Mechanical Differentials, 24 pp, Pic Design Corp.

357—Molded Packings, 8 pp, Greene, Tweed & Co.

358—Bonded Metal to Rubber Seals, 6 pp, Stillman Rubber Co.

FASTENING AND JOINING

341—Hi-temp Self-locking Nuts, 80 pp, Elastic Stop Nut Corp.

WEALTH OF VITAL INFORMATION . . .

NEW COMPONENTS

GENERAL ENGINEERING

332—Mechanical Integrator

333—Vibration Meter

NON-METALLIC MATERIALS, FINISHES

315—Delvin Extruded Rod

322—High-temperature Laminates

POWER TRANSMISSION

302—Stepless Adjustable Speed Drives

316—Miniature Speed Reducers

317—Heavy-duty Flexible Shafts

319—Spline Drive Is Optional

MECHANICAL PARTS

321—Plastic Tubing Insert

330—Miniature Instrument Bearings

FASTENING AND JOINING

305—Nonconductive Adhesive

ELECTRICAL, ELECTRONIC COMPONENTS

300—Thermal Multiswitch Control

303—Rotary Switch

304—Maintained-action Footswitch

306—Miniature Revolution Counter

307—Non-glare Panel Light

308 Manual Power Switch

309—Telephone relay

310—Electronic Tachometer

311—Printed Circuit Connectors

312—Subminiature Pilot Lights

314—High-pressure Solid Silver-to-Solid Silver Contacts

318—Electronic Control Device

320—Trimming Potentiometer

323—Solid-state Time Delay

324—Enclosed Precision Switch

325 Silicon-controlled Rectifiers

326—Electronic Delay Timers

328—Nuclear Delay Timer

329—Phase Sequence Relays

331—Rotary Potentiometers

HYDRAULIC, PNEUMATIC EQUIPMENT

301—Solenoid Air Valve

313—Miniature Pressure reducer

327—Hyraulic Motors and Pumps

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P6 P8 P10 P11 P12 P13 P14 P15 P16 P17
P18 P19 P20 P21 P22 P23 P24 P25 P26

*MULTIPLE Key No.	PRODUCT ADS Specific Product

Please print or type

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS
P6 P8 P10 P11 P12 P13 P14 P15 P16 P17
P18 P19 P20 P21 P22 P23 P24 P25 P26

*MULTIPLE Key No.	PRODUCT ADS Specific Product

Please print or type

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

MOTORS, ENGINES AND CONTROLS

351—Size 11 Servomotors, 16 pp, Helipot Div., Beckman Instruments Inc.

356—Size 8 Servomotors, 16 pp, Helipot Div., Beckman Instruments Inc.

ELECTRICAL, ELECTRONIC COMPONENTS

342—Electrical Switches and Terminals, 24 pp, Ark-Les Switch Corp.

348—Sectional Terminal Blocks, 12 pp, Buchanan Electrical Products Corp.

352—Electronic Wire and Cable, 16 pp, Alpha Wire Corp.

HYDRAULIC, PNEUMATIC EQUIPMENT

344—Control Valves, 16 pp, Ross Operating Valve Co.

350—Brass Tube and Pipe Fittings, 16 pp, Brabant Brass Mfg. Co.

- More information on advertised products
- More data on new materials and components
- Copies of catalogs and bulletins offered
- Free editorial reprints
- Your personal subscription to PRODUCT ENGINEERING

Get Complete Information Promptly... Use These Convenient, Time-Saving Cards

Issue of January 4, 1960
Product Engineering
Card expires March 4, 1960

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

Issue of January 4, 1960
Product Engineering
Card expires March 4, 1960

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

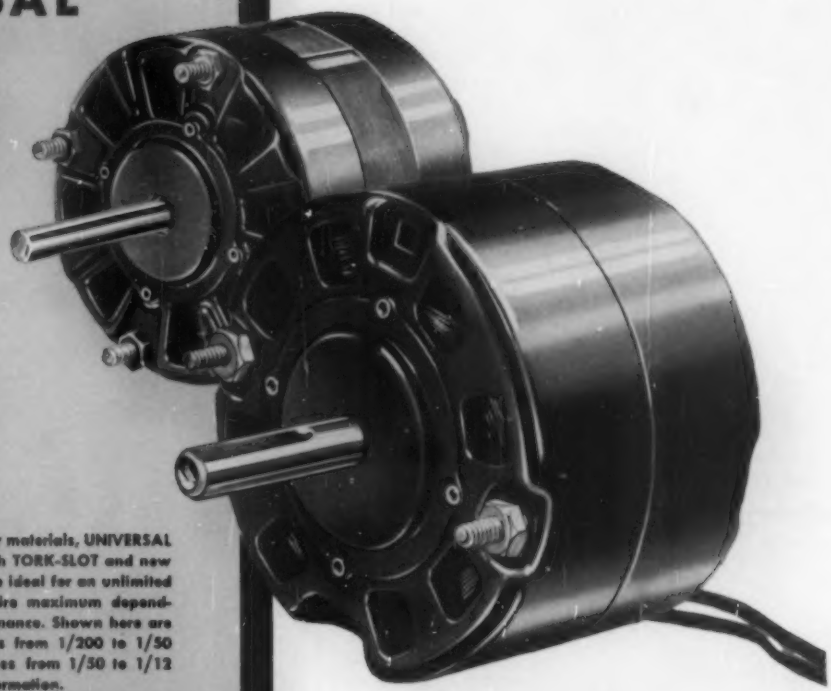
Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

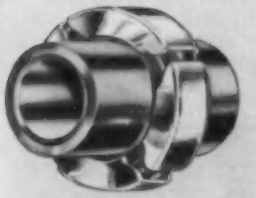
An Opportunity To Get More Information Quickly, Conveniently

UNIVERSAL ELECTRIC FRACTIONAL HP MOTORS

with improved flux control and new *free-aligning* bearing



Rugged, precision built with quality materials, UNIVERSAL ELECTRIC Fractional HP Motors with TORK-SLOT and new *free-aligning* Universal Bearing are ideal for an unlimited number of applications that require maximum dependability with a minimum of maintenance. Shown here are the re-designed Type 118 in sizes from 1/200 to 1/50 HP and the new Type 23 in sizes from 1/30 to 1/12 HP. Write today for complete information.



UNIVERSAL "FREE ALIGNING" BEARING

UNIVERSAL ELECTRIC motors also feature the new *free-aligning* Universal Bearing that eliminates fractional HP motor bearing problems due to misalignment. The new bearing, which has its axis of support in the center rather than at the end, is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load conditions. The bearing provides an easier starting motor that runs without a whisper of sound.

UNIVERSAL TORK-SLOT FLUX CONTROL

The operating efficiency and starting torque of UNIVERSAL ELECTRIC four-pole, shaded-pole fractional HP motors have been greatly improved by a patented reluctance slot. Called TORK-SLOT, this slot allows improved control over flux distribution and provides an *isolated* torque phase with a uniform air gap between yoke and rotor. Motors that incorporate the TORK-SLOT start easier and operate more efficiently over a wider range than motors with other types of reluctance slots.

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 12

CIRCLE 202 ON READER SERVICE CARD

First U.S. double-bed lathe... Le Blond's huge "Admiral"... assures spindle rigidity with Timken® bearings

IT'S a giant!... this lathe built by R. K. Le Blond Machine Tool Co. Named the "Admiral", it's the first U.S.-built double-bed lathe. And it weighs 75 tons, is 54 ft. 6 in. long, 120 in. wide. To maintain spindle rigidity under 50,000 lb. line load, Le Blond mounts it on Timken® tapered roller bearings. And for extra quality, the lathe ways are made of Timken 91140 steel. Le Blond uses Timken bearings to get:

1) *Special precision.* Timken bearings are made specifically for precision spindle applications.

2) *Extra load-carrying capacity.* Full-line contact between rollers and races gives Timken bearings extra capacity and their tapered design lets Timken bearings take *both* radial and thrust loads. They hold the spindle rigid.

3) *Extra toughness.* The bearing's heart—the steel—is the finest bearing steel available.

4) *Virtually eliminate friction.* Timken bearings are designed and precision-made to roll true.

For machines that perform better at lower cost, be sure the ones you buy or build are equipped with Timken tapered roller bearings. ***When you buy Timken bearings you get...***
1) Quality you can take for granted.
2) Service you can't get anywhere else.
3) The best-known name in bearings.
4) The pace setter in lower bearing costs. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

BETTER-NESS rolls on

TIMKEN®

tapered roller bearings

CIRCLE 203 ON READER SERVICE CARD